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Habitat Use, Movements, and Behavior of Shiny Cowbirds in Southwestern Puerto Rico.

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HABITAT USE, MOVEMENTS, AND BEHAVIOR OF SHINY COWBIRDS IN SOUTHWESTERN PUERTO RICO

A Dissertation

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Louisiana State University and Agricultural and
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in

The School of Forestry, Wildlife, and Fisheries

by
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M.S., Louisiana State University, 1985
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DEDICATION

This dissertation is dedicated to the memory of my late mother, Mary H. McKenzie, who looked forward to but will never realize the completion of my doctoral degree. The ability, desire, discipline, and perseverance necessary to complete this degree originated from her. Her constant love, support and encouragement will never be forgotten. Although I will miss her, the memories of her will never grow dim.

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ABSTRACT

Shiny Cowbirds were primarily located in six major areas of concentration. Of these, all but one was in mesquite woodland. Overall, cowbirds used mesquite woodland almost 75% of the time but use of this habitat varied among weekly periods and was linked to rainfall received during weekly periods prior to the observation. Habitat use of cowbirds and the time they spent eating particular prey items were most correlated with total rainfall received 2-5 weeks prior to the observation ($p=0.0067$ and $p=0.0149$, respectively). Major food items taken by cowbirds following periods of sufficient rainfall were caterpillars, berries and grass seeds. During periods of drought, cowbirds foraged on such food items as the leaves and inflorescences of mesquite, waste corn and other grains associated with agricultural and residential areas. Cowbirds appeared to prefer caterpillars when available. The availability of caterpillars was dependent primarily on the species, the host plant, and the amount of rainfall.

Shiny Cowbirds often foraged in mixed-species flocks with Yellow-shouldered Blackbirds and/or Greater Antillean Grackles. When icterid flocks contained at least 50 cowbirds, blackbirds and grackles associated with cowbirds when caterpillars were available as prey ($p<0.001$).

Main species of caterpillars eaten by cowbirds were larvae of the noctuid moths Mocis latipes and Melipotis ochrodes. Other species of caterpillars were seasonal and available to cowbirds for short periods

of time (usually 5 days or less).

On average cowbirds foraged, rested and preened, and drank and bathed about 68%, 31%, and 1% of the time, respectively. Nine incidences of allopreening were observed between cowbirds and Yellow-shouldered Blackbirds. Twenty-five incidences of sunning by cowbirds were observed.

As with cowbirds, blackbirds and grackles have apparently adapted to seasonal, caterpillar outbreaks in southwestern Puerto Rico. Recent caterpillar outbreaks are probably related to an abundance of new plant hosts associated with habitat changes. Mesquite and associated exotic grasses have replaced much of the orginal, native savannahs. Although exotic, mesquite is probably compatible with the native ucar, and should be protected and managed to benefit the endangered blackbird.

INTRODUCTION

The Shiny Cowbird (Molothrus bonariensis), a general brood parasite native to South America, Trinidad, and Tobago, has rapidly expanded its range northwest through the Lesser and Greater Antilles, (Danforth 1932; Bond 1946, 1956, 1961, 1964, 1966, 1967, 1971, 1973, 1976, 1977, 1984; Grayce 1957; Biaggii 1963; Robertson 1962; Buckley and Buckley 1970; Ricklefs and Cox 1972; Post and Wiley 1977a; A.O.U. 1983; Arendt and Vargas-Mora 1984; Cruz et al. 1985), and has recently reached North America (Smith and Sprunt 1987, Imhof 1989, Langridge 1989, Ogden 1989). As with the Brown-headed Cowbird (Molothrus ater) (Mayfield 1961, 1965; Rothstein et al. 1980; Brittingham and Temple 1983; Verner and Ritter 1983) and Brewer's Blackbird (Euphagus cynanocephalus) (Walkinshaw and Zimmerman 1961, Stepney and Power 1973) in North America, the recent, accelerated range expansion of the Shiny Cowbird has been attributed to land clearing and associated agricultural and animal husbandry practices (Friedmann 1929, Diamond 1973, Post and Wiley 1977b, Arendt and Vargas-Mora 1984, Friedmann and Kiff 1985, Cavalcanti and Pimentel 1988).

Because the avifauna of the West Indian islands have evolved in the absence of any brood parasite, they have not developed defense mechanisms against brood parasitism (Friedmann 1971, Cruz et al. 1985, Wiley 1985b). Consequently, the Shiny Cowbird has been implicated in the decline of many Caribbean species (Post and Wiley 1977b, Post 1981, Wiley 1985b, Cruz et al. 1985, Cruz and Wiley 1989).

The Yellow-shouldered Blackbird (Agelaius xanthomus) is endemic to

Puerto Rico and is primarily restricted to Mona Island and southwestern Puerto Rico (A.O.U. 1983). Prior to hurricane Hugo of 1989, a small population of 15-20 birds existed near Ceiba on the southeastern end of the island (Post and Wiley 1976). Most of this population apparently perished during the hurricane (A.O.U. 1989). Between the late 1800's and ca. 1940, the species was considered abundant and was widespread throughout the island (Taylor 1864; Wetmore 1916, 1927; Danforth 1931, 1936). Post and Wiley (1976) believed that the bird was still common and widespread in Puerto Rico as late as the 1940's. Although no research or observations were taken on the Yellow-shouldered Blackbird between 1940 and 1972, many researchers believe that the population declined steadily during this period (Post and Wiley 1976, 1977a, 1977b; Post 1981; Cruz et al. 1985; Wiley 1985b). Post and Wiley (1976) estimated the world population of Yellow-shouldered Blackbirds in 1976 at 2,400 individuals (2,000 in coastal southwestern Puerto Rico, 200 in coastal southeastern Puerto Rico, and 200 on Mona Island). By April 1982, the population was estimated at 720 individuals (U.S. Fish and Wildlife Service 1983). In 1976, the U.S. Fish and Wildlife Service listed the Yellow-shouldered Blackbird as an endangered species and critical habitat was established (U.S. Fish and Wildlife Service 1976). A recovery plan was written for the species in 1983 (U.S. Fish and Wildlife Service 1983).

Post and Wiley (1976) investigated the decline of the Yellow-shoulderd Blackbird and listed six probable factors leading to the precipitous decline in the species' numbers. These were: 1)

reduction in feeding habitat due to an increase in monoculture practices by island farmers, 2) reduction in mangrove [Rhizorphora mangle L., Laguncularia racemosa (L.), Avicennia germinans (L.) L.] nesting areas, 3) introduction of harmful pests (primarily rats--Rattus rattus and R. norvegicus, and small Indian mongoose--Herpestes javanicus) into lowland Puerto Rico, 4) range expansion and increase in numbers of the Pearly-eyed Thrasher (Margarops fuscatus) in southeastern Puerto Rico, 5) as much as 18.7% of the population of Yellow-shouldered Blackbirds being infected by Fowl Pox, and 6) range expansion and increase in numbers of the Shiny Cowbird into breeding areas of the Yellow-shouldered Blackbird. Most researchers agreed that the Shiny Cowbird was the main cause for the decline of the Yellow-shouldered Blackbird in Puerto Rico (Post and Wiley 1976, 1977a, 1977b, Post 1981, U.S. Fish and Wildlife Service 1983, Cruz et al. 1985, Wiley 1985a,b).

The Shiny Cowbird is now one of the most common species in lowland Puerto Rico (U.S. Fish and Wildlife Service 1983) and the endangered Yellow-shouldered Blackbird is one of the main host species for the cowbird. Brood parasitism of Yellow-shouldered Blackbirds by Shiny Cowbirds has been reported as high as 94.2% by Cruz et al. (1985) and 95% by Wiley (1985b). Although Shiny Cowbirds are considered as extreme host generalists (Friedmann et al. 1977; Friedmann and Kiff 1985; Mason 1986a, 1986b; Wiley 1988), primary host species can remain heavily parasitized even when their numbers are greatly reduced and considered rare (Wiley 1985b). Thus, continued parasitism by a brood parasite can cause local depression and even extinction of host species (Wiley 1985b). Populations of the endangered Kirtland's Warbler

(Dendroica kirtlandii) in Michigan declined dangerously after continued parasitism by the Brown-headed Cowbird (Mayfield 1960, 1965, 1972, 1973, 1975, 1977, 1978; Walkinshaw 1983). The Shiny Cowbird has also had an extreme depressive effect on the reproductive success of other host species including Rufous-collared Sparrow (Zonotrichia capensis) in Argentina (King 1973, Fraga 1978), Yellow Warbler (Dendroica petechia) in Barbados (Bond 1966), and the House Wren (Troglodytes aedon) on Grenada (Bond 1971). In Puerto Rico, Wiley (1982a, 1985a) reported that species whose nests were parasitized by Shiny Cowbirds hatched 12% fewer eggs and fledged 67% fewer of their own chicks than non-parasitized pairs.

Although Post and Wiley (1976) concluded that there was "probably nothing that could be done to control the cowbird," they believed that certain management practices could be used to reduce its impact on the Yellow-shouldered Blackbird. Removal of cowbirds from blackbird breeding areas is one effective method used to enhance the reproductive success of blackbirds (Wiley 1982b, U.S. Fish and Wildlife Service 1983). Wiley (1985a) stated that "at present, cowbird control appears to be the most effective management tool for the recovery of parasitized avian populations." In North America, the removal of Brown-headed Cowbirds from breeding areas of the endangered Kirtland's Warbler has been helpful in reversing downward trends for the warbler (Mayfield 1973, 1977, 1978; Shake and Mattsson 1975; Anderson and Storer 1976; Kelly and DeCapita 1982; Walkinshaw 1983).

In Puerto Rico, information on the habitat use, movements, and behavior of Shiny Cowbirds could be useful in modifying existing

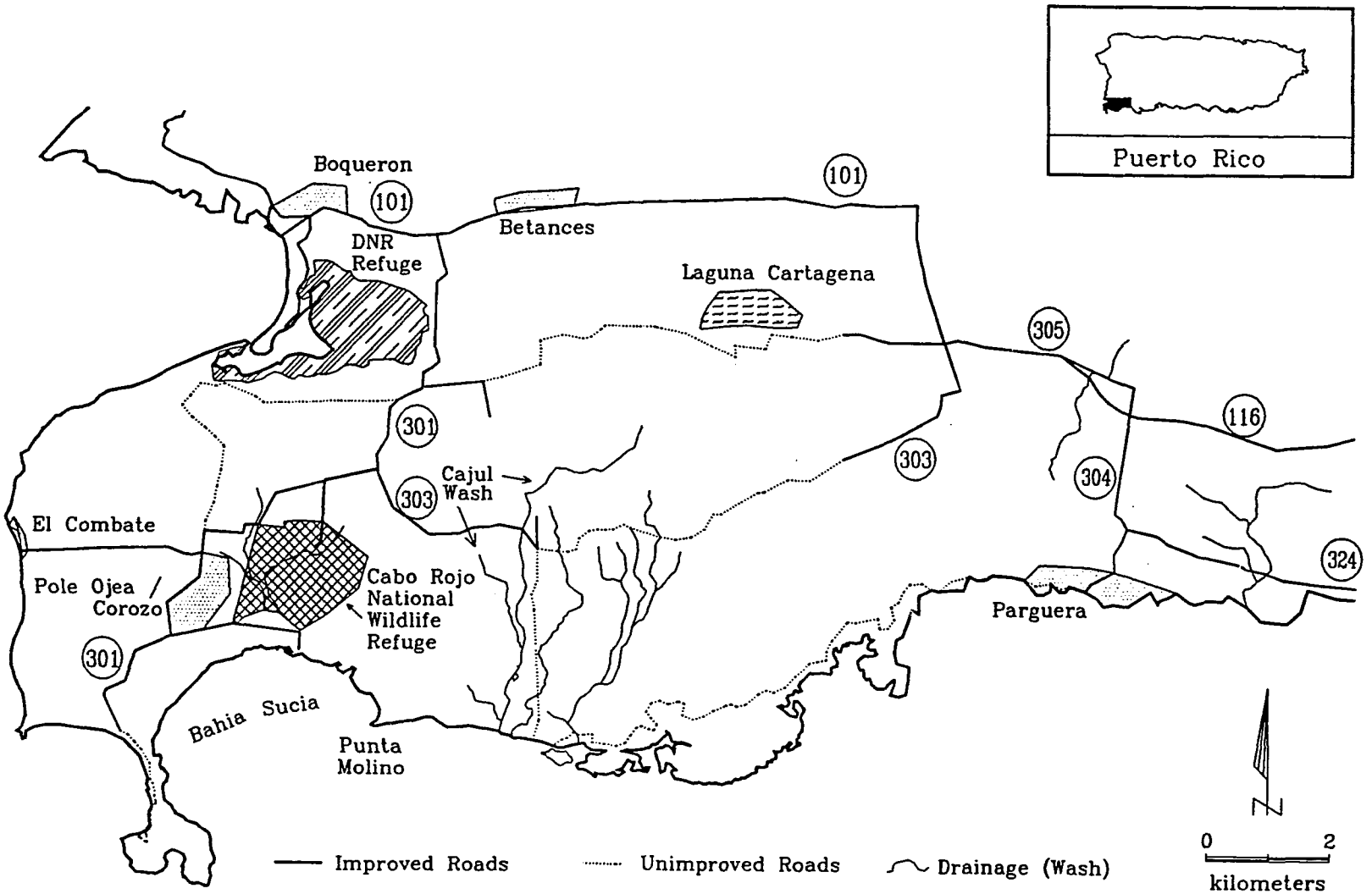
cowbird removal programs. The objectives of this study were: 1) to obtain information on habitat use, movements, and foraging behavior of Shiny Cowbirds, 2) to identify concentration areas of foraging Shiny Cowbirds, 3) to locate flocks of Shiny Cowbirds and to assess the association of this species with Greater Antillean Grackles and Yellow-shouldered Blackbirds, 4) to conduct behavioral observations of Shiny Cowbirds and develop activity budgets, 5) to assess the appropriateness of using patagial markers for monitoring habitat use and movements of Shiny Cowbirds, and 6) to provide management recommendations.

DESCRIPTION OF THE STUDY AREA

The study was conducted in southwestern Puerto Rico and extended from the Cabo Rojo National Wildlife Refuge northwest to Boqueron, east to Lajas, southwest to Parguera and Papayo Salinas, and west to the Cabo Rojo lighthouse (Fig. 1). This area includes approximately 160 km^2, or ca. 16,000 hectares.

Because of constant land-clearing practices for pasture, agricultural crops, and urban development, the vegetational and ecological zones of southwestern Puerto Rico have changed significantly (Liogier and Martorell 1982) since the discussions of Gleason and Cook (1927), Cook and Gleason (1928), Garcia-Molinari (1952), and Ewel and Whitmore (1973). Southwestern Puerto Rico experiences the highest average temperature and lowest average precipitation of any area on the island (Cook and Gleason 1928, Garcia-Molinari 1952, Ewel and Whitmore 1973). Cook and Gleason (1928) designated this area as being "xerophytic," while Ewel and Whitmore (1973) described it as "subtropical dry forest." The vegetation on the southwestern end of the island is characteristic of such xeric conditions. Although little of the original forest remains in southwestern Puerto Rico, isolated pockets of native vegetation can still be found along "...the streams, fence rows, roadsides, and small thickets on rocky outcrops too steep for agriculture or pasture" (Cook and Gleason 1928:72). Because of the drastic changes in vegetational types and lack of descriptive analyses on the ecological zones of southwestern Puerto Rico since Gleason and Cook (1927), Cook and Gleason (1928), and Garcia-Molinari (1952), I

Figure 1. Location of study area, southwestern Puerto Rico, 1987-1988.


Puerto Rico
Boqueron
101
DNR
Refuge
Betances
101
Laguna Cartagena
305
301
303
Cajul
Wash
303
304
116
El Combate
Pole Ojea /
Corozo
Cabo Rojo
National
Wildlife
Refuge
324
Parguera
301
Bahia Sucia
Punta
Molino
Improved Roads
Unimproved Roads
Drainage (Wash)
0
2
kilometers

provide updated information here. Although Ewel and Whitmore (1973) added to our knowledge of recent vegetational changes along the southern coast of Puerto Rico, the extreme southwestern coast and adjacent areas between Boqueron and LaParguera were not discussed.

Southwestern Puerto Rico is currently characterized by a mosaic of nine vegetation types: 1) mangrove forests, 2) salt flats, 3) mesquite and semi-evergreen woodland, 4) littoral woodland (Beard 1944, 1955) or beach thickets, 5) coastal scrub or thorn woodland, 6) deciduous woodland, 7) dry and wet pasture, 8) agriculture, and 9) residential and roadside ornamentals. Major plant species often vary within habitat types where soil types and available moisture differ, and where grazing intensities are dissimilar. When appropriate, I discuss these variations in plant composition. Unless otherwise stated, nomenclature of plants follows Liogier and Martorell (1982).

Mangrove Forests and Adjacent Salt Flats

Mangrove forests extend from Boqueron to Papayo Salinas along coastal bays and offshore cays. Major species are red mangrove (Rhizophora mangle L.), white mangrove [Laguncularia racemosa (L.) Gaertn. f.], black mangrove [Avicennia germinans (L.) L.] and button mangrove (Conocarpus erectus L.). Directly inland from the mangrove swamps are highly saline salt flats composed mostly of a ground cover of Batis maritima L. and Sesuvium portulacastrum L., with scattered patches of Heliotropium curassavicum L., white mangrove, black mangrove, Portulaca quadrifida L., Sporobolus virginicus (L.) Kunth, Chloris inflata Link, Salicornia bigelovii Torrey, and Bouteloua

americana (L.f.) Scribn.

Mesquite Woodland/Semi-evergreen Forest

An area extending inland from the salt flats to the base of the Sierra Bermeja and Penones de Melones mountain ranges was formerly designated by Cook and Gleason (1928) as an ucar (Bucida buseras L.) climax forest and a grass savannah by Garcia-Molinari (1952). Because of land clearing for agriculture and pasture, this area is now dominated primarily by an overstory of mesquite (Prosopis pallida H. & B. ex Willd.) HBK. , interspersed with ucar, guayacan (Guaiacum officinale L.), tamarind (Tamarindus indicus L.), Pithecellobium dulce (Roxb.) Benth., Leucaena leucocephala (Lam.) de Wit, and Pisonia albida (Heimerl) Britton ex Standl. In many areas the understory is dominated by grasses such as Cenchrus ciliaris L., Bothriochloa pertusa (L.) A. Camus, Panicum maximum L., or Dichanthium annulatum (Forssk.) Stapf. Common understory shrubs and herbaceous plants include Lantana involucrata L., Cordia globosa (Jacq.) HBK. var. humilis (Jacq.) I.M. Johnst., Cordia stenophylla Alain, Castela erecta Turp., Solanum persicifolium Dunal, Clenome stenophylla Klotzsch, Achyranthes aspera L. var. aspera, Heliotropium angiospermum Murray, Acalypha ostyrifolia Ridd., Desmanthus virgatus (L.) Willd., Bouchea prismatica (L.) Kuntze, Sida abutifolia Mill., Wissadula amplissima (L.) R.E. Fries, Croton lobatus L., Portulaca quadrifida L., Ruellia tuberosa L., Capraria biflora L., and Opuntia repens Bello. Common vines within this habitat include Tournefortia volubilis L., Commicarpus scandens (L.) Standl., Stigmaphyllon periplocifolium (Desf.) A. Juss., and Cissus trifoliata L.

L.

Additional overstory species found along washes within mesquite woodland/semi-evergreen forest include Albizia lebbeck (L.) Benth, Crescentia cujete L., Tabebuia heterophylla (DC.) Britton, Swietenia mahagoni Jacq., Bauhinia monandra Kurz, and Piscidia carthagenensis Jacq. Also included in the understory are Lantana camara L., Acacia farnesiana (L.) Willd., Jatropha gossypifolia L., Ayenia insulicola Cristobal, Datura stramonium L., Bromelia pinguin L., Setaria rariflora Mikan, and Brachiaria echinulata (Mez) Parodi. Vines such as Acacia retusa (Jacq.) Howard, and Macfadyena unguis-cati (L.) A. Gentry are also present.

At Boqueron, additional overstory species within the habitat include Cocos nucifera L., Cordia laevigata Lam., and Stahlia monosperma (Tul.) Urban, while Sporobolus jacquemontii Kunth, and Brachiaria subquadripara (Trin.) Hitchc. are major understory grasses. Near La Parguera, additional, important overstory species are Crescentia linearifolia Miers, Adelia ricinella L., and Randia aculeata L., while Pictetia aculeata (Vahl) Urban, Catesbaea parviflora Sw., and the cacti Pilosocereus royenii (L.) Byles & Rowley, Consolea rubescens (Salm-Dyck) Lem., and Melocactus intortus (Miller) Urban, are major components of the understory.

Littoral Woodland (Beach Thickets)

A strip of deep, beach sand extends from Bahia Sucia west to near the town of El Combate. Cook and Gleason (1928) designated this area as a "coastal thicket" and Beard (1944, 1955) described such habitat as

"littoral woodland." Near the beach major plants are Ipomoea pes-caprae (L.) R.Br. ssp. brasiliensis (L.) von Oostr., and Spartina patens (Ait.) Muhl.

Farther inland, major overstory trees include Coccoloba uvifera (L.) C., Pisonia albida, Coccoloba diversifolia Jacq., Krugiodendron ferreum (Vahl) Urban, Rochefortia acanthophora (DC.) Griseb., Randia aculeata, Colubrina arborescens (Miller) Sarg., Jacquinia arborea Vahl, Clerodendrum aculeatum L., Erythoxylum areolatum L., Erithalis fruticosa L., Canella winterana (L.) Gaertn., Piscidia carthagenensis, and an occasional ucar, guayacan, or mesquite. Important understory plants include Pithecellobium unguis-cati (Mart.) DC., Argythamnia candicans Sw., Bumelia ovata (Lam.) A. DC., Amyris elimifera L., Capparis cynophallophora L., Tabebuia heterophylla, Lantana involucrata L., Gossypium hirsutum var. marie-galante (Watt) J. B. Hutchinson, Helicteres jamaicensis Jacq., Catesbaea parvifolia, Conocarpus erectus, Crossopetalum rhacoma Crantz, Eugenia maleolens Pers., Croton lucidus L., Croton discolor Willd., Sida abutifolia, Portulaca halimoides L., Ernodea littoralis Sw., Urechites lutea (L.) Britton, Fimbristylis cymosa R. Br. ssp. spathacea (Roth) T. Koyama, Capraria biflora, Suriana maritima L., Batis maritima L, Bromelia pinguin L., Aristida adscensionis L., Bouteloua americana (L.f.) Scribn., Sporobolus virginicus, Chloris radiata, and Mariscus planifolius (L.C. Rich) Urban. Pilosocereus royeni, Opuntia dillenii (Ker-Gawl.) Haw., Opuntia repens, and Leptocereus quadricostatus (Bello) Britton & Rose are common understory cacti.

Coastal Scrub or Thorn Woodland

Some of the land between areas adjacent to the Pitahaya Roost and La Parguera is dominated by thick, coastal scrub. Such habitat was designated as cactus scrub or thorn woodland by Beard (1944). Dominant overstory trees associated with this habitat are Bursera simaruba (L.) (L.) Sarg., and Pisonia albida, with a few scattered Plumeria alba L., ucar, guayacan, and mesquite. Characteristic understory shrubs include Lantana involucrata, Croton discolor, Melochia tomentosa L., and Croton betulinus Vahl, while common cacti are Pilosocereus royenii, Leptocereus quadricostatus, Hylocereus trigonus (Haw.) Safford, Consolea rubescens, and Opuntia dillenii. The grasses Chloris inflata and Sporobolus pyramidatus are common within the few scattered openings.

Toward Punta Molina, near Bahia Sucia, small pockets of limestone can be found within the coastal scrub. In such habitat, ucar, mesquite, Pisonia albida, Tabebuia heterophylla, Guapira discolor (Sprengel) Little, and Crescentia cujete, are the major overstory species, while the understory is dominated by Lantana involucrata, Wedelia lanceolata DC., Croton discolor, Croton lucidus, Melochia tomentosa, Melochia pyramidata L., Turnera diffusa Willd., Castela erecta, Adelia ricinella, Pithecellobium unguis-cati, Pictetia aculeata, Cordia stenophylla, Cordia globosa var. humilis, Guaiacum sanctum L., Amyris elemifera, Exostema caribaeum (Jacq.) Schult. in L., Rauvolfia viridis Willd. ex Roem. & Schult., Tephrosia senna HBK., Ruellia tuberosa, Hibiscus phoeniceus Jacq., Krameria ixina L., Heliotropium angiospermum, Achyranthes aspera L. var. aspera, Rivina

humilis L., Opuntia repens, Bouteloua repens (HBK.) Scribn. & Merr., Setaria utowanaea (Scribn.) Pilger, Mollugo verticillata L., Clenome stenophylla, Siphonoglossa sessilis (Jacq.) Gibson, Synedrella nodiflora (L.) Gaertn., Petiveria alliacea L., and Spermacoce confusa Rindle & Gillis. Important species of vines in this zone are Tournefortia volubilis, Stigmaphyllon periplocifolium, Celosia nitida Vahl, and Commicarpus scandens.

Deciduous Woodland

Major trees in the deciduous woodland habitat type are ucar, Bursera simaruba, Pisonia albida, Clusia rosea Jacq., Thouinia portoricensis Radk., Bourreria succulenta Jacq., Rauvolfia nitida, Ziziphus reticulata (Vahl) DC., Colubrina arborescens, Colubrina elliptica (Sw.) Briz. & Stern, Zanthoxylum martinicense (Lam.) DC., Zanthoxylum monophyllum (Lam.) P. Wilson, Erythroxylum areolatum L., Guazuma ulmifolia Lam., Coccoloba diversifolia Jacq, and an occasional guayacan. Common understory species are Amyris elemifera, Bauhinia monandra, Guaiacum sanctum, Pictetia aculeata, Olyra latifolia L., Lasiacis divaricata (L.) Hitchc., and Leersia monandra Sw. Important vines in this habitat include Acacia retusa, Macfadyena unguis-cati, and Tragia volubilis L., while common cacti are Hylocereus trigonus and Leptocereus quadricostatus.

Some windswept summits of deciduous woodland near La Parguera are dominated by Leptochloopsis virgata (Poir.) Yates, Croton discolor, and Lantana involucrata.

The upper slopes of the Sierra Bermeja are dominated by Thrinax

morrisii H. Wendl., Myrciaria floridbunda (West ex Willd.) Berg., Hymenaea courbaril L., Guapira fragrans Dum.-Cours.) Little, Pilosocereus royenii, Melocactus intortus, Croton discolor, Lantana involucrata, Wedelia lanceolata, Piptocoma antillana Urban, Pictetia aculeata, while important understory grasses include Aristida chaseae Hitchc., Aristida portoricensis Pilger, Bouteloua repens, and scattered patches of Digitaria eggersii (Hack.) Henrard (McKenzie et al. 1989).

Dry and Wet Pastures

Dry pastures are dominated by the grasses Cenchrus ciliaris, Bothriochloa pertusa, Dichanthium annulatum, Panicum maximum, Sporobolus pyramidatus, Digitaria decumbens Stent, Brachiaria subquadripara, Cynodon dactylon (L.) Pers., Cynodon nlemfuensis Vanderhyst, Digitaria bicornis (Lam.) Roem. & Schult., and Heteropogon contortus (L.) Beauv. ex Roem. & Schult. Main species of grasses associated with wet pastures include Panicum maximum, Paspalum virgatum L., Paspalum millegrana Schrad, Eriochloa polystachya HBK., Brachiaria purpurascens (Raddi) Henr., and Paspalum notatum Flugge.

Agriculture

Major crops in southwestern Puerto Rico include sugar cane, pineapple, melon, eggplant, pumpkin, avocado, papaya, cucumber, yucca, and peppers. Rice culture is not a major crop and is limited to the Lajas Experiment Station.

Residential and Roadside Ornamentals

Ornamentals are commonly planted along roadsides and at residences in southwestern Puerto Rico. Common species include Cocos nucifera, Delonix regia (Bojer ex Hook.) Raf., Albizia lebbeck, Albizia procera (Roxb.) Benth., Annona muricata L., Tamarindus indicus, Pithecellobium saman (Jacq.) Benth., Magnifera indica L., Spathodea campanulata Beauv., Guazuma ulmifolia, and Peltophorum pterocarpum (DC.) Back. & Heyna.

LITERATURE REVIEW

Shiny Cowbirds, Yellow-shouldered Blackbirds and Greater Antillean Grackles (Quiscalus niger) are common in southwestern Puerto Rico and share communal roosts (Post and Post 1987). A historical review of habitat changes and the benefits of flocking and communal roosts in southwestern Puerto Rico could provide insight into the evolution of mixed-species flocks of icterids there. Although a number of studies have been conducted assessing the reproductive interactions of blackbirds and cowbirds (e.g. Post and Wiley 1976, 1977a, b; Wiley 1985; Cruz et al. 1985), few studies have examined the foraging associations of the three species in mixed-species flocks.

Habitat Changes

Much of southwestern Puerto Rico was formerly classified as an ucar climax forest or grassland savannah that was characterized by an overstory of ucar with an understory of native grasses (Cook and Gleason 1928, Garcia-Molinari 1952). Because of land clearing for agriculture and grazing, much of the native vegetation was replaced with introduced species, especially mesquite and the exotic grasses found in the understory of this habitat (Garcia-Molinari 1952, Liogier and Martorell 1982, Little and Wadsworth 1989). Although ucar is still common in southern Puerto Rico (Little and Wadsworth 1989), it is probably currently less abundant than it was formerly. A brief, historical examination of the introduction and range expansion of mesquite and exotic grasses in Puerto Rico is essential to an

understanding of habitat changes on the southwestern end of the island.

Little and Wadsworth (1989) briefly discussed the introduction of mesquite into Puerto Rico and stated that its range, "including its geographic varieties"... was "from southwestern United States (Texas to Kansas, Utah, and California) south through Mexico and Central America to Colombia and Venezuela and perhaps naturalized southward." Burkart (1976 a,b) however, determined that the species was native to the western, dry parts of Colombia, Ecuador, and Peru, and stated that it had been introduced in Puerto Rico, the Hawaiian Islands, the Marquesas, and in parts of Brazil, India, and Australia.

Although mesquite is not native to Puerto Rico, it is now common in southwestern Puerto Rico (Little and Wadsworth 1989). Mesquite was introduced ca. 1600, as a source of railroad cross ties for the now defunct railroad in Puerto Rico. The species rapidly spread in savannahs, pastures, and abandoned agriculture fields.

Although Humphrey (1949) believed that elimination of natural periodic fires was the most important factor responsible for the spread of mesquite in the southwestern United States, Fisher (1977) suggested that the expansion was due to the "rapid influx of large numbers of grazing animals." Cattle readily eat the nutritious pods (Fisher et al. 1959, Fisher 1977, Mooney et al. 1977). The seeds remain viable for a long time (Martin 1948), and they germinate readily after passing through the digestive tract of most grazing animals (Fisher et al. 1959, Haas et al. 1973). Haas et al. (1973) reported that mesquite seed that had passed through the alimentary canals of livestock had a higher germination rate than those that had not. Therefore, livestock

represent a dispersal agent; cattle were probably responsible for the expansion of mesquite in Puerto Rico (Little and Wadsworth 1964, 1989).

Mesquite is presently used in Puerto Rico for charcoal and fence posts and is an important commodity in the southwestern corner of the island. Fisher et al. (1959) reported that mesquite was formerly used for fuel, charcoal, and fence posts in Texas. Because of its value for ornament, shelter in arid conditions, timber, fuel, and forage (fruits), Burkart (1976b) concluded that mesquite "must be encouraged in other warm and dry countries." In Hawaii, Hosaka and Ripperton (1944) considered mesquite to be "the most valuable tree in the Territory."

Most species of grasses that are the major ground cover in mesquite woodland are also not native to Puerto Rico, but were introduced as experimental forage grasses. These include Guinea grass (Panicum maximum), saline buffel grass (Cenchrus ciliaris), angleton blue stem (Dichanthium annulatum), and hurricane grass (Bothriochloa pertusa). Based on Colon's (1930:284) report, Alberts and Garcia-Molinari (1943) stated that Guinea grass was "first introduced at Arroyo on the south side of the island early in the sixteenth century from seed that was in straw that was used for bedding of the human cargo of a slave ship that came directly from Africa." Roberts (1948), however, indicated that Guinea grass was introduced into Puerto Rico from Africa as early as the 15th century. By 1948, pastures in southwestern Puerto Rico were so dominated by Guinea grass that areas covered by this grass were desginated as the "Great Plains" of Puerto

Rico (Roberts 1948). Liogier and Martorell (1982:204) indicated that the grass was "very common in fields and banks at lower and higher elevations."

Although hurricane grass was not reported as being present on the island by Britton & Wilson (1924), or Cook and Gleason (1928), Alberts and Garcia-Molinari (1943) listed the species as a pasture grass for Puerto Rico and indicated that cattle found the foliage unpalatable. By 1982 the grass had become so common in southern Puerto Rico that Liogier and Martorell (1982:195) described the species as being "abundant in fields and waste grounds at lower and middle elevations." When Britton & Wilson (1924) wrote their Flora of Puerto Rico, only one locality was known for saline buffel grass and angleton blue stem. In their ecological survey of the island, Cook and Gleason (1928) did not mention either grass as being components of the understory for habitats along the southern coast. By 1943, however, angleton blue stem had become an important pasture grass along the south-central coast (Alberts & Garcia-Molinari 1943), and by 1952 Garcia-Molinari (1952) reported that the species covered an area of "several thousand acres from Juan Diaz to Coamo and Santa Isabel." Additionally, Garcia-Molinari (1952) stated that Dichanthium annulatum had overtaken many areas formerly occupied by Guinea grass and Chloris inflata, (a native species that was a part of the ucar climax forest near the coast).

By 1943, saline buffel grass was an important pasture grass in the "savanna region on the south side of the island" (Alberts and Garcia-Molinari 1943). Although Liogier and Martorell (1982:196)

described the range of saline buffel grass as "on dry limestone hills and roadsides in southern Puerto," they provided no information on the abundance of the species there. Currently, saline buffel grass (Fig. 2) is the dominant grass in the understory of mesquite woodland between Corozo and La Parguera, while hurricane grass and angleton blue stem are the dominant species in many open and heavily grazed pastures. Guinea grass is presently abundant in many pastures, hillsides, roadsides, and along most washes and streams, especially inland from the southwestern coast where higher rainfall enables this species to out compete saline buffel grass, angleton blue stem, and hurricane grass.

The current open to semi-open character of mesquite woodland in southwestern Puerto Rico probably approximates the original ucar climax forest and grassland savanna. Grazing is common in mesquite woodland and probably helps maintain the savanna-like character of this habitat. The open nature of mesquite woodland could enable mixed-species flocks of foraging icterids to spot predators and realize other benefits from such associations.

Benefits of Flocking and Communal Roosting

The benefits of flocking have been long debated. Powell (1985) reviewed the sociobiology of mixed-species flocks and tested hypotheses concerning the adaptive significance of flocking. Based on analyses of spatial use and foraging niche characteristics of flocking species, Powell concluded that a decrease in the likelihood of predation was a major function of mixed-species associations. Other authors have

Figure 2. Cenchrus ciliaris in flower, southwestern Puerto Rico, 1988.

supported the view that protection from predators was probably the main benefit of flocking (Croze 1970, Morse 1970, Vine 1971, Willis 1972, Page and Whitacre 1975, Trusman 1975, MacDonald 1977, Kenward 1978, Abramson 1979, and Orians 1985). Allee (1938) suggested that flocks under attack benefited from a "confusion effect" when they moved in concert, because the grouping and flocking behavior of the prey made it difficult for predators to single out an individual. Tinbergen (1953) indicated that European Starlings (Sturnus vulgaris) that flew in large flocks had definite survival advantages against flying raptors.

Rudebeck (1950) compared the relative success of Eurasian Sparrowhawks (Accipiter nisus) attacking single versus flocked prey and found that the success in capturing lone birds was higher than with flock members. Moynihan (1962) and Powell (1985) hypothesized that the presence of birds in flocks could discourage predators.

Icterids foraging together in a large mixed-species flock are probably wary and constantly on the lookout for predators. Verbeek (1964) noted that flocks of Brewer Blackbirds (Euphagus cynanocephalus) were constantly on the alert and would flush due to sudden loud noises or the "sudden appearance of a moving object." Verbeek (1972) observed Yellow-billed Magpies (Pica nuttalli) feeding in grassland and stated that the birds would frequently "flee to nearby trees in response to predators or to alarm calls from other birds," and added that this behavior resulted in an "intermittent pattern of feeding, flying, and resting."

Although protection from predators may be a major benefit of social foraging, other factors could be important to the formation of such

flocks. Morse (1970) suggested that a "more important explanation" for the advantages gained by mixed-species, foraging flocks was the ability of such species "to exploit available resources in a maximally effective manner, given that other species with overlapping spectra of habitat utilization" were "present and utilizing common resources." In other words, individuals in mixed-species flocks would realize improvements in foraging efficiency (e.g., Rand 1954, Cody 1971, Austin and Smith 1972, Hoffman et al. 1981, Grubb 1987). Others have advocated that the main benefit of flocking was a combination of increased foraging efficiency and increased protection from predators (Morse 1977, Abramson 1979). Herrera (1979) asserted that the foraging success of birds foraging in flocks was greater than birds foraging alone. Additional theories have been proposed to explain the significance of social foraging. One theory is that birds learn the location of food sources by seeing groups of foraging individuals at concentrated food patches. This "local enhancement" (Thorpe 1956:32, Hinde 1961) is common among many colonial species that forage in flocks (Crook 1965, Ward 1965, Turner 1965, Krebs et al. 1972, Krebs 1974, Kushlan 1977, Andersson et al. 1981, Caldwell 1981).

Several authors have advocated that social or observational learning (Alcock 1969a,b) of food sources is likely to be an important advantage of flocking in those birds whose food occurs in localized patches and was abundant within the patches (Crook 1965, Ward 1965, Zahavi 1971). When foraging in inter- and intra-specific flocks, flock members often choose foods that other birds in the flock are choosing or alter their feeding behavior (Murton 1971a, Williamson and Grey

1975, Greig-Smith 1978). Such "imitative foraging" (Greig-Smith 1978), where unsuccessful birds "copy" successful individuals, has been documented in several studies (e.g., Krebs et al. 1972; Murton 1971a,b; Duecker 1976, Mason and Reidinger 1981, 1982). Mason and Reidinger (1981) concluded that observational learning of new foods by Red-winged Blackbirds foraging in flocks was probably the reason this species could locate and exploit crops. Alcock (1973) experimented with young Red-winged Blackbirds and found that, through locational and visual cues, the birds could learn the location and type of food. Croze (1970) and Murton (1971a) suggested that crows and pigeons returned to locations where they found food in the past. Royama (1970) believed that titmice exploited productive patches in their environment by searching for specific locations or backgrounds, rather than for specific visual cues possessed by the prey.

Many authors have supported Ward and Zahavi's (1973) information center hypothesis that states that communal roosts serve as information centers where roosting birds disseminate information on the location of concentrated food sources (Horn 1968; Siegfried 1971; Krebs 1974; Houston 1976; Des Granges 1978; Custer and Osborn 1978; DeGroot 1980; Rabenold 1983; 1987a,b; Brown 1986; Gaston 1987; Greene 1987; Waltz 1987; Vessem and Draulans 1987; Gori 1988). One of the main assumptions of the theory is that a transfer of information of the patchy food concentrations takes place between successful and unsuccessful birds (Hunt and Hunt 1976, Erwin 1978, Viksne and Janaus 1980). Unsuccessful birds then follow successful foragers from the roost or colony to good feeding areas on subsequent trips. The communication

necessary for the the transfer of such information may be active (i.e., volitional: Ward and Zahavi 1973, Erwin 1977, Evans 1982) or passive (i.e., nonvolitional: Krebs 1974; 1978; Waltz 1982; 1987).

Many have questioned the significance of the information center hypothesis (Swann 1975; Broom et al. 1976; Loman and Tamm 1980; Myers 1980; Andersson et al. 1981; Fleming 1981; Bayer 1982; Evans 1982b, 1983; Post 1982; Caccamise and Fischl 1985; Kiis and Mooler 1986; Mock et al. 1988; Hebblethwaite and Shields 1990).

As discussed by Evans (1982b), another caveat of the information center hypothesis is that leader birds should be those individuals that were successful on their previous foraging trips. Evans (1982b) developed a flock formation model on the basis that "all birds are potential flock leaders, leadership-follower status being dependent only on the relationship between a bird's own departure time if acting alone, social attractions, and the time since preceding birds have left the colony or foraging site." Waltz (1983) supported Evans' (1982b) assertion that leaders associated with information centers are randomly selected and stated, "over time, individuals may be as likely to be leaders as followers, depending on fluctuations in particular food patches."

The "assembly point hypothesis" of Evans (1982a) is an alternative to the information center hypothesis. It claims that colonies and roosts function as "assembly points," where dispersed foragers reunite and thereby maintain local population densities at levels sufficient to facilitate group foraging. The assembly point hypothesis assumes that leaders and followers obtain benefits from leaving in flocks, and flock

leaders and followers are not necessarily determined by prior foraging success. Bayer (1982) postulated that flocks could result from social bonding between flock members that forage together and arrive or depart to and from a colony or a roost.

The main purpose of communal roosts may also be the enhanced predator protection derived from physical characteristics of the roost site and/or the presence of roost mates (Hamilton 1971, Post 1982, Weatherhead 1983). Caccamise and Fischl (1985) believed that secondary species choose large communal roosts to minimize risks associated with the selection of roost sites. Pulliam (1973) suggested that predator protection alone could not be the reason birds gather in large communal roosts because such benefits were likely asymptotic with maximum benefits achieved at relatively small group sizes (i.e., <100). Some authors have suggested that more than one advantage was responsible for the evolution of communal roosting in birds (Crook 1965, Morse 1970, Lazarus 1972, Loman and Tamm 1980, Weatherhead 1983). Caccamise and Morrison (1986) postulated that major communal roosts were "aggregations of individuals selecting the roosting sites nearest rich food sources," and labelled this theory as a "patch sitting" hypothesis.

METHODS AND MATERIALS

Capture of Cowbirds and Marking Technique

Shiny Cowbirds were trapped on the Cabo Rojo National Wildlife Refuge (Fig. 1) using 3 "walk-in" traps modified from the designs developed by John F. Heisterberg, USDA/APHIS/ADC, Denver Wildlife Research Center, 334-15th St., Bowling Green, Kentucky, and Zajanc and Cummings (1965) (Fig. 3). The traps were provided with water and baited with commercially available parakeet seed. Live Shiny Cowbird decoys were used to attract other cowbirds into the trap. Each cowbird was banded with a U.S. Fish and Wildlife Service aluminum leg band, and a patagial wing marker (after Kochert et al. 1983, Cummings 1987, Stromborg et al. 1988) was placed on the right patagium. Sex and age were recorded for each individual. Patalgial markers were constructed from water, heat, and chemical resistant polyethylene, vinyl laminate (Safety Flag Co. of America, P.O. Box 1005, Pawtucket, Rhode Island 00862) (Fig. 4). Each marker was sequentially numbered with a black marking ink that was resistant to wear and weather (Allflex, G.C. Hanford Mfg. Co., P.O. Box 1017, Syracuse, N.Y. 13201). Markers were attached using a "Buttoneer II" fastener gun (Dennison Mfg. Co., Framingham, Mass. 01701) and nylon fasteners (Buttoneer Fasteners, P.O. Box 557, Franklin, Mass. 02308) (Fig. 5). White tags were placed on males and red-orange tags on females (Fig. 4).

Release and Relocation of Marked Cowbirds

Marked birds were released at the capture site on the Cabo Rojo National Wildlife Refuge (see Apps. A, B for sex, age, leg band

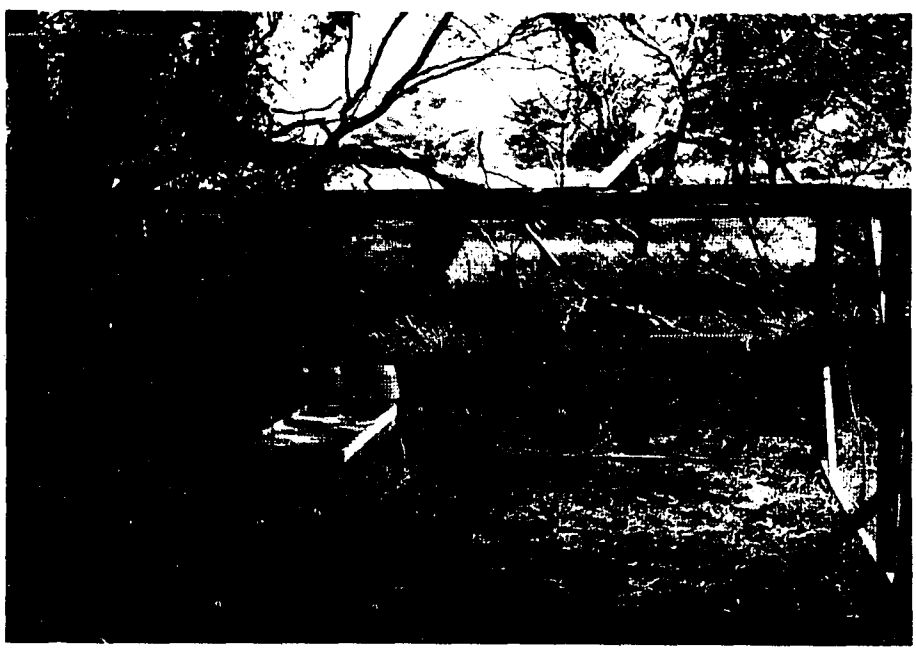


Figure 3. Traps used for capturing Shiny Cowbirds, southwestern Puerto Rico, 1987. The trap is about 1.5 m high.

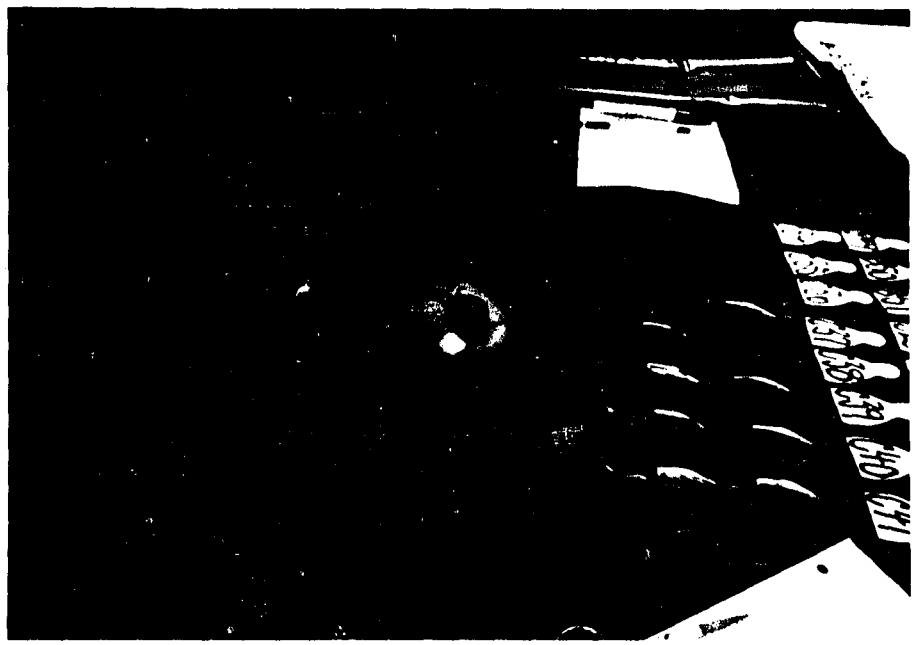


Figure 4. Patalgial tags used in marking Shiny Cowbirds, southwestern Puerto Rico, 1987.

Figure 5. Buttoneer Fastener marking gun (scale: 3 cm= ca. 15 cm) used for attaching patalgial tags, southwestern Puerto Rico, 1987.

numbers, patagial marker numbers, and release date for each marked bird) in 1987.

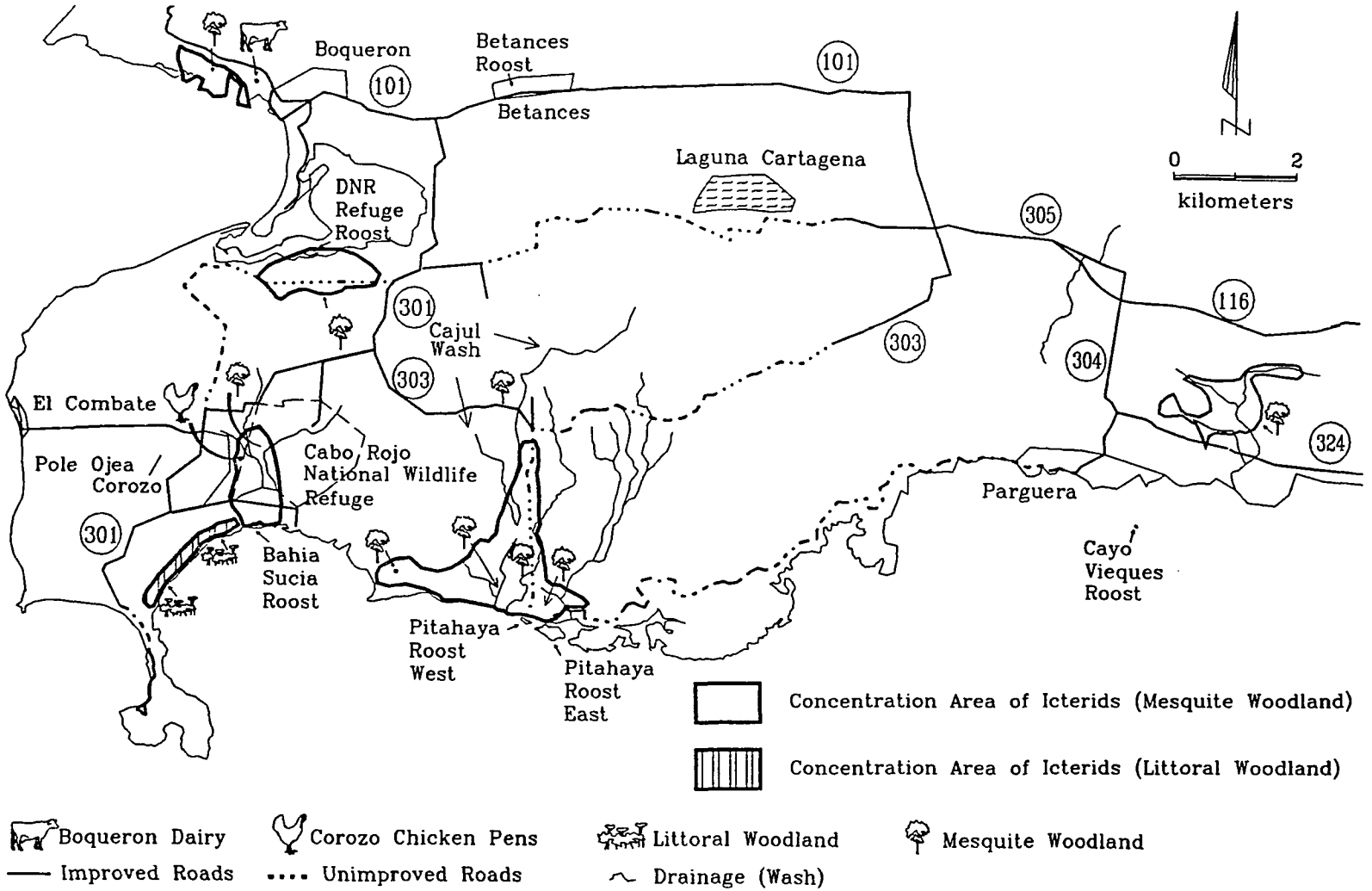
Attempts were made to identify marked birds at known icterid roosts (Fig. 6) at dawn. Marked birds soon dispersed into different flocks and different roost sites after their release. Consequently, I rotated the days I followed flocks that had potentially marked individuals. As marked individuals left their respective roost, I obtained a compass bearing on their flight line and attempted to relocate these birds by walking in that direction and searching potential habitats equally.

Data Collection

Once a flock was located, I recorded information on marked birds as long as they remained in sight. To obtain information on habitat use and what food items cowbirds ate, I recorded sex, tag number, date, location, minutes of observation in a particular habitat, and the number of minutes marked cowbirds were observed foraging on a particular food item. Food items taken by marked cowbirds that could not be identified in the field were collected for later identification. Birds were observed through 10 X 40B binoculars or a 15-60X spotting scope. When flocks moved, I again took a compass bearing on their flight line and followed them, again searching all available habitats equally. I followed or searched for marked birds from daylight until dusk. Data were summed for weekly periods (31 May-6 June through 13-19 December) and equal effort was given within each period.

Minutes of habitat use, minutes marked cowbirds foraged on a

Figure 6. Icterid roosts and concentration areas of Shiny Cowbirds, southwestern Puerto Rico, 1987-1988.


Boqueron
Betances Roost
Betances
101
Laguna Cartagena
0
2
kilometers
DNR Refuge Roost
305
116
301
Cajul Wash
303
304
El Combate
Pole Ojea
Corozo
Cabo Rojo National Wildlife Refuge
324
Parguera
Bahia Sucia Roost
Cayo Vieques Roost
Pitahaya Roost West
Pitahaya Roost East
Concentration Area of Icterids (Mesquite Woodland)
Concentration Area of Icterids (Littoral Woodland)
Boqueron Dairy
Corozo Chicken Pens
Littoral Woodland
Mesquite Woodland
Improved Roads
Unimproved Roads
Drainage (Wash)

particular food item, and minutes for each weekly period were converted to percent. Subsets of individuals within a flock often acted independently. For example, some portions of a flock of foraging cowbirds constantly were flushing from the ground to the overstory directly above, and after resting for a few minutes, returned to the ground to forage. Subsets within a flock often remained in the overstory to rest and preen. Additionally, different subsets within a flock often foraged on different items. For example, in mesquite woodland during certain seasons, it was not uncommon to see one subset foraging on caterpillars found in the grass understory, another subset foraging on caterpillars found behind the bark and crevices of mesquite, and still another subset feeding on the berries of understory shrubs. To monitor differences in what prey items were eaten by each subset, marked birds served as focal individuals. The total time the flock spent foraging on different food items and the total time the flock spent on a particular activity was calculated by summing the time for each subset. To determine the amount of time the flock spent in a particular habitat, the total time in each habitat was summed for each hour. If different subsets within the flock were foraging on separate items during an hourly period, but the flock remained in that habitat, the total time of habitat use for the flock could not exceed 60 minutes. For example, if during one hourly period in mesquite woodland, one subset foraged on the ground for 40 minutes and preened and rested for 20 minutes, and another subset foraged in mesquite for 30 minutes, foraged in shrubs for 20 minutes, bathed for 1 minute, and preened and rested for 9 minutes, then the total time recorded for the

flock in mesquite woodland for that hour was 60 minutes.

Data were only collected for subsets and flocks that contained marked birds. Because of their movements and position in different vegetative types, it was often impossible to read the tag numbers of all marked birds within a particular subset. Consequently, it was impossible to statistically analyze individual habitat use or the time individuals spent foraging on different food items. Percentages, therefore, represent the habitat use and time spent foraging on different food items for cowbird flocks within weekly periods.

In my initial summarizations, I noted that habitat use by Shiny Cowbirds and what food they were observed eating were somewhat cyclic and appeared to reflect differences in rainfall received during the study period. Consequently, I used a Pearson correlation analysis and modeled the percent habitat use and the percent food items eaten by Shiny Cowbirds for a particular period as a function of rainfall prior to the observation period. In the analysis of the time cowbirds spent foraging on food items, I lumped those food items that probably became available to cowbirds following periods of rain (i.e., caterpillars, berries, and seeds). Analyses was weighted by the total time observed. Due to insufficient sample sizes, observations of 24-30 May, 16-22 August, 23-29 August, 29 November-5 December, 6-12 December, and 13-19 December were not included in the analyses.

Unknown insect food items were collected, fixed in 10% formalin, and stored in 70% ethanol until identified. When cowbirds were observed eating the fruits of plants I could not identify in the field, I collected the fruits and subsequently identified the plants.

From my initial observations I concluded that caterpillars were important food items of Shiny Cowbirds. I also observed the same caterpillars were often taken by Greater Antillean Grackles that frequently associated with cowbirds. To confirm my field observations I examined stomach (proventriculus and gizzard combined) contents of cowbirds and grackles for the presence of caterpillars. These birds were collected during fall 1987 and 1988. In 1987 (16-18 November), personnel of the Louisiana State University Museum of Natural Science, Baton Rouge, Louisiana, collected seven Shiny Cowbirds on our study area. In 1988 (31 August-6 September), I collected 14 cowbirds and 38 grackles from mesquite woodland where caterpillar outbreaks were observed.

To identify concentration areas of foraging Shiny Cowbirds, I plotted on a map locations that cowbird flocks frequented throughout the study. A grouping of at least 50 cowbirds was arbitrarily chosen as being a large flock. When such flocks were located, I recorded the associating species and the major food taken by flock members. I used a Fisher's exact probability test (Siegel 1956:96-101) to assess if there was a relationship between members of a flock containing at least 50 Shiny Cowbirds and the major food items taken by flock members.

Data on cowbird activity budgets were obtained by recording minutes marked cowbirds were observed foraging, resting and/or preening, and drinking and/or bathing. Resting and preening were combined because it was often impossible to separate the two activities. Additionally, because other activities (e.g., calling or singing) were often done simultaneously with others (e.g., resting or

preening), it was impossible to further delineate such activities. To monitor differences in activity budgets of Shiny Cowbird flocks during weekly periods, marked birds served as focal individuals. As with habitat use and the time cowbirds spent foraging on particular food items, the total time the flock spent performing a particular activity was calculated by summing the time for each subset within the flock. The total time cowbirds performed each activity was summed for each hour. Because of their movements and position in different vegetative types, it was often impossible to read the tag numbers of all marked birds within a particular subset. Consequently, it was impossible to compare the activity budgets of individual birds. Percentages, therefore, represent activity budgets for cowbird flocks within weekly periods. In addition to recording information on activity budgets, I recorded other facets of cowbird behavior during 1987 and 1988.

To assess the effectiveness of using patagial markers I took notes on tag wear and loss and calculated the minimum time tags were retained on selected birds. Personnel of the Puerto Rican Department of Natural Resources occasionally trapped birds I had marked during an ongoing cowbird removal program. Before releasing marked birds, Department personnel recorded the trap location, and the sex and tag numbers of trapped individuals. This information was used for tag retention calculations.

RESULTS AND DISCUSSION

Habitat Use, Movements, and Foraging Behavior of Shiny Cowbird Flocks

A total of 383 cowbirds was marked during the study (169 males and 214 females). Habitat use and what food items cowbirds were observed eating varied somewhat among weekly periods and appeared to reflect differences in rainfall received on the study area prior to an observation period (Figs. 7, 8, 9; Apps. C, D).

Throughout the study period, Shiny Cowbirds used mesquite woodland almost 75% of the time (Fig. 10; App. C). Use of mesquite woodland by Shiny Cowbirds was most correlated with total rainfall 2-5 weeks prior to the observation (n=23, df=22, r^2=0.30, p=0.0067). Cowbirds used 3 types of mesquite woodland: ungrazed (occurring mainly on the Cabo Rojo National Wildlife Refuge), moderately grazed (Fig. 11), and heavily grazed (Fig. 12). As with habitat use, the time cowbirds spent eating caterpillars, berries, or seeds, were most correlated with total rainfall 2-5 weeks prior to the observation (n=23, df=22, r^2=0.25, p=0.0149).

I located Shiny Cowbirds in six major concentration areas (Fig. 6). Of these, 5 were in mesquite woodland: Cabo Rojo National Wildlife Refuge, proposed Voice of America site and adjacent woodland, land adjacent to the Puerto Rican Department of Natural Resources' Refugio de Aves (hereafter designated as the DNR refuge), woodland west of Boqueron, and areas adjacent to Papayo Salinas just ENE of La Parguera. The concentration area not in mesquite woodland was in littoral woodland south of Corozo (Fig. 6).

Figure 7. Habitat use by Shiny Cowbirds (percent of observations), by weekly period, southwestern Puerto Rico, 31 May- 28 November 1987 (n= 45,744 minutes; ca. 762 hrs.). Weekly periods correspond to 26 periods consecutively numbered with week number one being the 31 May-6 June 1987 period, and week number 26 being the 22-28 November 1987 period.

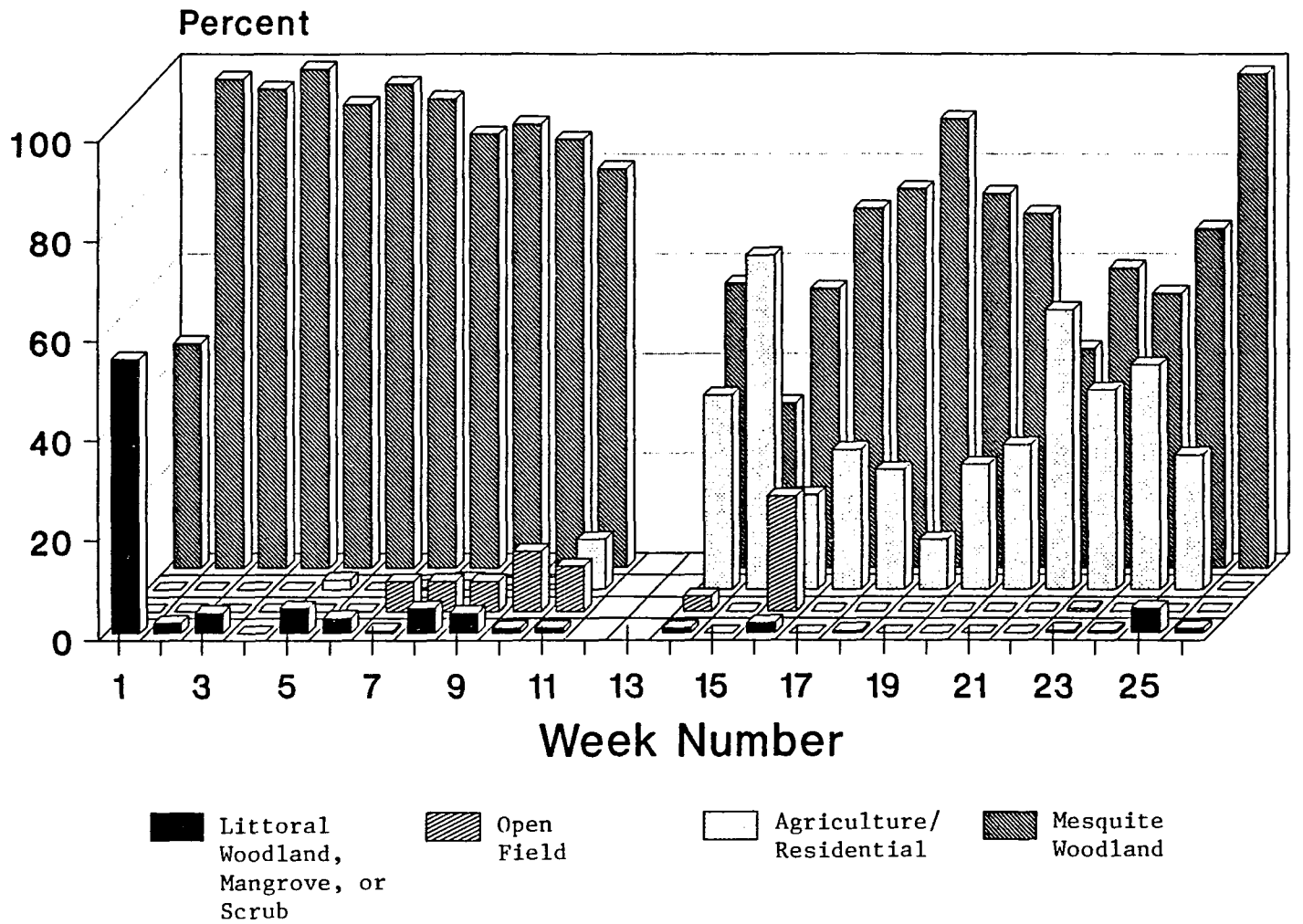
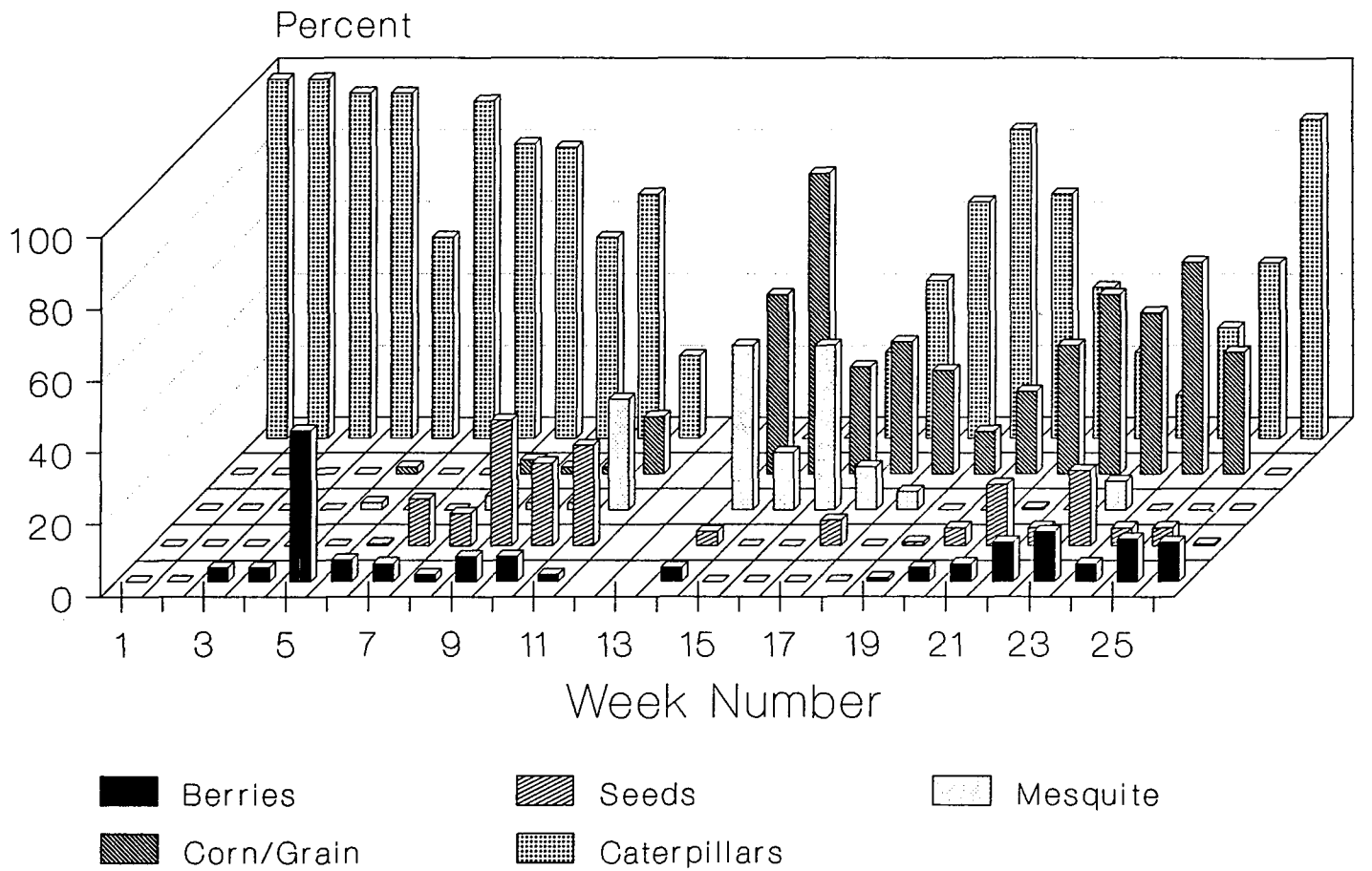

Percent
100
80
60
40
20
0
1
3
5
7
9
11
13
15
17
19
21
23
25
Week Number
Littoral Woodland, Mangrove, or Scrub
Open Field
Agriculture/ Residential
Mesquite Woodland

Figure 8. Prey items taken by Shiny Cowbirds (percent of observation), by weekly period, southwestern Puerto Rico, 10 May- 28 November 1987 (n= 29,298 minutes; ca. 488 hrs.). Weekly periods correspond to 26 periods consecutively numbered with week number one being the 31 May-6 June 1987 period, and week number 26 being the 22-28 November 1987 period.


Percent
100
80
60
40
20
0
1
3
5
7
9
11
13
15
17
19
21
23
25
Week Number
Berries
Seeds
Mesquite
Corn/Grain
Caterpillars

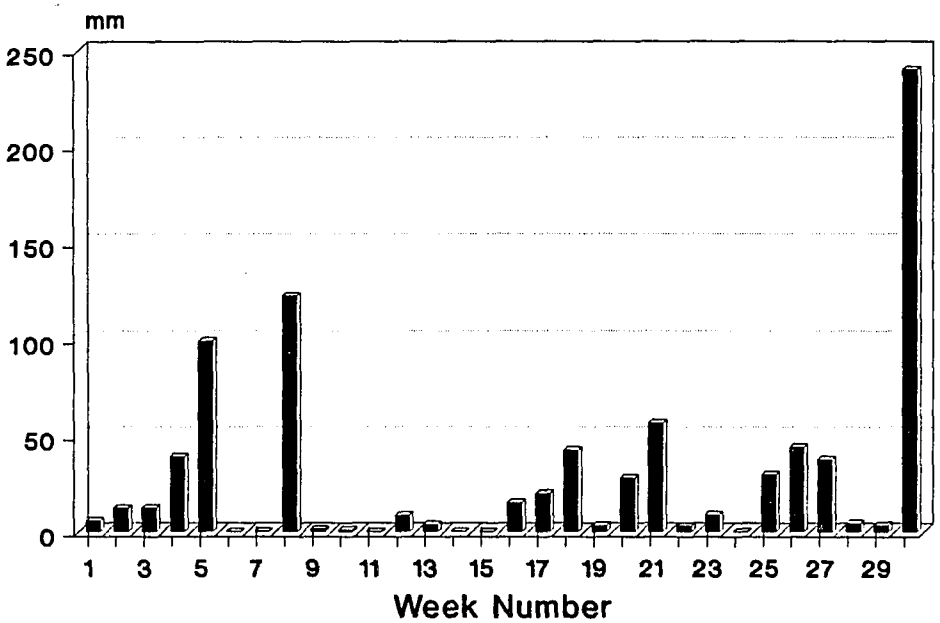


Figure 9. Weekly rainfall received on the Cabo Rojo National Wildlife Refuge, southwestern Puerto Rico, 1987. Weekly periods correspond to 30 periods consecutively numbered with week number one being the 3-9 May 1987 period, and week number 30 being the 22-28 November 1987 period.

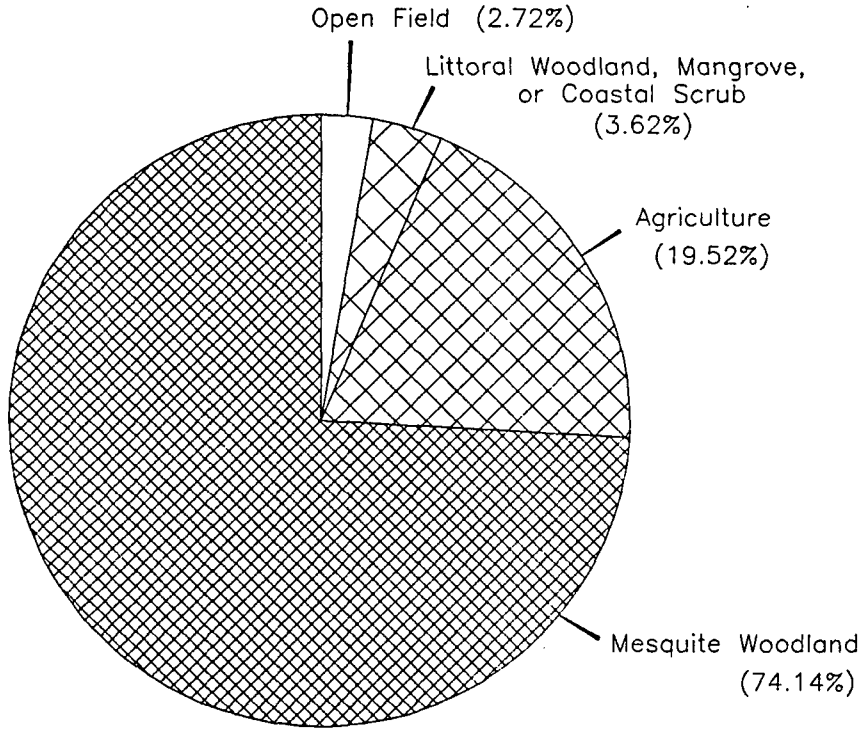


Figure 10. Habitat use by Shiny Cowbirds (percent of observations), southwestern Puerto Rico, 1987 (n= 45,744 minutes; ca. 762 hrs.).

Figure 11. Moderately grazed mesquite woodland used by Shiny Cowbirds, southwestern Puerto Rico, 1987-1988.

Figure 12. Heavily grazed mesquite woodland used by Shiny Cowbirds, southwestern Puerto Rico, 1987-1988.

Throughout the study, cowbirds foraged primarily on the caterpillar larvae of Mocis latipes, Melipotis ochrodes, Spodoptera spp., Melipotis sp., Heliothis sp., and Anticarsia gemmatalis (Table 1). They also were observed foraging on berries (e.g., Cordia globosa var. humilis, and Tournefortia volubilis), and on seeds of grasses (e.g., Brachiaria subquadriparia, Panicum maximum, Cenchrus ciliaris, and Brachiaria echinulata) (Table 1).

Forty-five flocks containing at least 50 Shiny Cowbirds were located throughout the study (Table 2). When caterpillars were the major prey item, Greater Antillean Grackles, and Yellow-shouldered Blackbirds often associated with cowbird flocks (Table 2). When there were at least 50 cowbirds in a flock and caterpillars were the major prey item, grackles and blackbirds associated with the flock more so than would be expected by random chance ($p<0.001$).

Habitat Use and Caterpillar Availability

Habitat use by Shiny Cowbirds was apparently related to food availability, especially the availability of caterpillars. For example, cowbirds used mesquite woodland for nine of the first ten periods and foraged primarily on caterpillars (Figs. 7, 8; Apps. C, D). The only exception to this pattern was the use of littoral woodland by cowbirds during the first period (31 May- 6 June: Fig. 7; App. C). Use of this habitat, however, was apparently based on an outbreak of Melipotis sp. on fresh foliage of Pithecellobium unguis-cati.

The availability of caterpillars was apparently dependent on the

Table 1. Species of caterpillar larvae, berries, and seeds (percent of total observations) eaten by Shiny Cowbirds, southwestern Puerto Rico, 1987 (n= 19,159 minutes; ca. 319 hrs.).

Caterpillar larvae		Seeds		Berries	
Species	Percent	Species	Percent	Species	Percent
Mocis latipes	53	*Brachiaria subquadriparia*	56	*Cordia globosa* var. *humilis*	47
Melipotis ochrodes	24	*Panicum maximum*	23	*Tournefortia volubilis*	46
Melipotis sp.	9	*Cenchrus ciliaris*	11	*Lantana* spp.	7
Unidentified spp.	7	*Brachiaria echinulata*	10	Unknown	<1
Heliothis sp.	5	*Cynodon dactylon*	<1		
Anticarsia gemmatalis	2	*Eleusin indica*	<1		
Thecla simaethis	<1	*Pennisetum purpureum*	<1		

Table 2. Composition of icterid flocks and prey items when flocks contained at least 50 Shiny Cowbirds, southwestern Puerto Rico, 1987-1988 (n= 43).

Date	Number of Shiny Cowbirds	Number of Greater Antillean Grackles	Number of Yellow-shouldered Blackbirds	Prey Item
1987				
1 June	50	25	0	caterpillars
2 June	100	25	0	caterpillars
3 June	100	25	2	caterpillars
4 June	50	25	0	caterpillars
19 June	75	25	5	caterpillars
20 June	100	30	5	caterpillars
25 June	100	50	0	caterpillars
26 June	100	50	0	caterpillars
6 July	150	40	0	caterpillars
8 July	50	30	15	caterpillars
9 July	25	30	15	caterpillars
10 July	300	300	30	caterpillars
11 July	400	400	30	caterpillars
15 July	200	50	0	caterpillars
18 July	200	50	0	caterpillars
19 July	400	50	4	caterpillars
25 July	600	50	20	caterpillars
27 July	500	50	20	caterpillars
31 July	500	100	25	caterpillars
4 Aug.	200	0	0	grass seeds
5 Aug.	50	25	5	caterpillars
2 Sep.	150	0	0	waste grain
3 Sep.	200	0	0	waste grain
4 Sep.	150	0	0	waste grain
5 Sep.	100	0	0	waste grain
6 Sep.	100	0	0	waste grain
10 Sep.	200	0	0	waste grain
13 Sep.	75	200	15	caterpillars
15 Sep.	100	50	10	caterpillars
17 Sep.	100	75	15	caterpillars
21 Sep.	200	100	5	caterpillars
24 Sep.	300	100	5	caterpillars
26 Sep.	300	200	15	caterpillars
29 Sep.	500	300	5	caterpillars
2 Oct.	300	200	15	caterpillars
4 Oct.	1000	1000	25	caterpillars
8 Oct.	300	500	30	caterpillars
10 Oct.	500	700	50	caterpillars

Table 2. Continued.

Date	Number of Shiny Cowbirds	Number of Greater Antillean Grackles	Number of Yellow-shouldered Blackbirds	Prey Item
1987				
12 Oct.	700	1200	100	caterpillars
18 Oct.	50	1000	100	caterpillars
20 Oct.	600	3000	300	caterpillars
24 Oct.	100	300	50	caterpillars
2 Nov.	75	0	0	waste grain
1988				
3 Sep.	200	50	50	caterpillars
7 Sep.	100	200	1	caterpillars

species of moth, the amount of rainfall, and the host plant. The caterpillars of Melipotis sp., Heliothis sp., Anticarsia gemmatalis (Hubner), and Thecla simaethis (Drury) were seasonal and available for short periods. Although thousands of caterpillars of Melipotis sp. were associated with the infestation on Pithecellobium unguis-cati in littoral woodland during the 31 May- 6 June period, caterpillars were only available to cowbirds for 4 days. The second outbreak of Melipotis sp. occurred on Pithecellobium dulce in mesquite woodland west of Boqueron (Fig. 6) during the 4-10 October period and caterpillars were available for about 5 days.

An outbreak of the "ucar" caterpillar (Heliothis sp.: Table 1) occurred on fresh foliage of Bucida buseras in mesquite woodland just north of the Pitahaya Roosts (Fig. 6) during 7-13 June, and caterpillars were available to cowbirds for 4 days. Some ucars were severly infested with caterpillars of Heliothis sp., while other trees were unaffected.

The only observation of cowbirds foraging on larvae of Thecla simaethis (Family LYCAENIDAE) was in mesquite woodland on the Cabo Rojo National Wildlife Refuge, 2 October 1987. The host plant, ballon vine (Cardiospermum halicacabum var. microcarpum (HBK.) Blume, was growing on a dessicated pond bottom with a thick overstory of Parkinsonia aculeata L. The larvae of this butterfly were foraging on the developing seeds within the ballon pod.

Shiny Cowbirds were observed foraging on the larvae of the velvet bean caterpillar (Anticarsia gemmatalis) during 1-7 and 8-14 November, just northeast of the Pitahaya Roosts. Larvae of this moth were

feeding on leaflets of Tephrosia cinerea (L.) Pers.

Caterpillars of Mocis latipes (Figs. 13, 14, 15) and Melipotis ochrodes (Fig. 16) were the most frequently prey observed taken by Shiny Cowbirds and accounted for 53% and 24% of the observations, respectively (Table 1).

Observational results were supported by the 1987 and 1988 stomach analyses (Tables 3-5). In 1987, 86% of the stomachs of Shiny Cowbirds collected on the study area contained larvae of Melipotis ochrodes (Table 35). In 1988, 100% of the stomachs of Shiny Cowbirds collected on the study area contained larvae or pupae of noctuid moths (Table 4: 86% of the stomachs contained pupae or larvae of Mocis latipes and 14% contained larvae of Melipotis ochrodes). Additionally, in 1988, 82% of the stomachs of Greater Antillean Grackles contained larvae or pupae of noctuid moths (Table 5: 39% contained larvae or pupae of Mocis latipes and 77% contained larvae of Melipotis ochrodes).

Melipotis ochrodes forages on the leaves of mesquite during the night and hides behind the bark and in crevices of mesquite during the day (Martorell 1975). Mocis latipes forages on the blades of various species of grasses (POACEAE), primarily Cenchrus ciliaris, Panicum maximum, Bothriochloa pertusa, Chloris inflata, Sporobolus pyramidatus, Cynodon dactylon, and Dichanthium annulatum (Martorell 1975; pers. obs.).

The differences in the species composition of caterpillars in the stomachs of grackles and cowbirds collected on the study area apparently reflected the differences in bill morphology between the two species, and availability of caterpillars. The apparent preference of

Figure 13. Caterpillar larva of Mocis latipes foraging on blades of Panicum maximum, southwestern Puerto Rico, 1987.

Figure 14. Caterpillar larvae of Mocis latipes removed from blades of Panicum maximum and Cenchrus ciliaris, southwestern Puerto Rico, 1988.

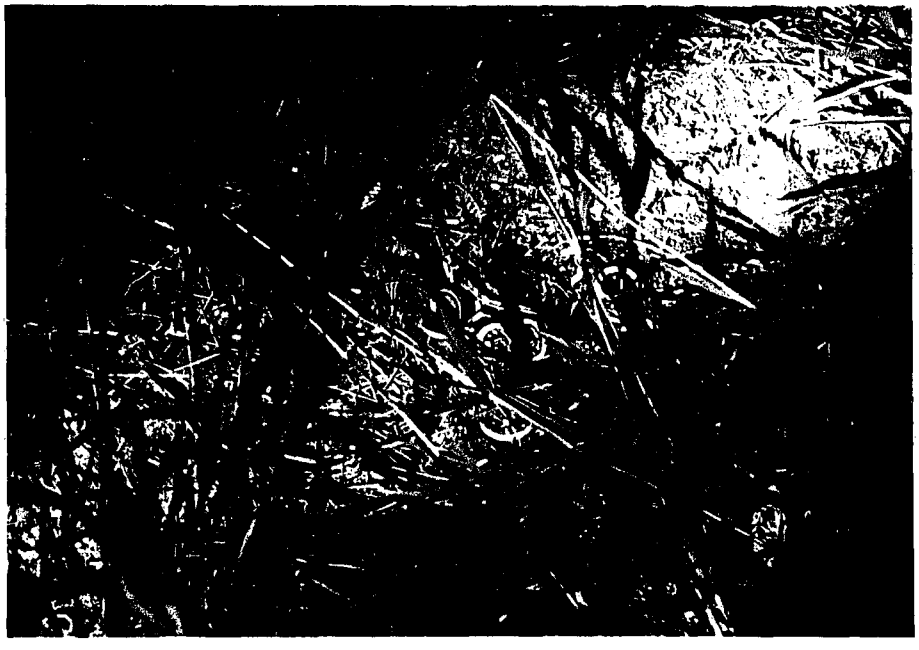


Figure 15. Caterpillar larvae of Mocis latipes removed from blades of Bothriochloa pertusa, southwestern Puerto Rico, 1988.

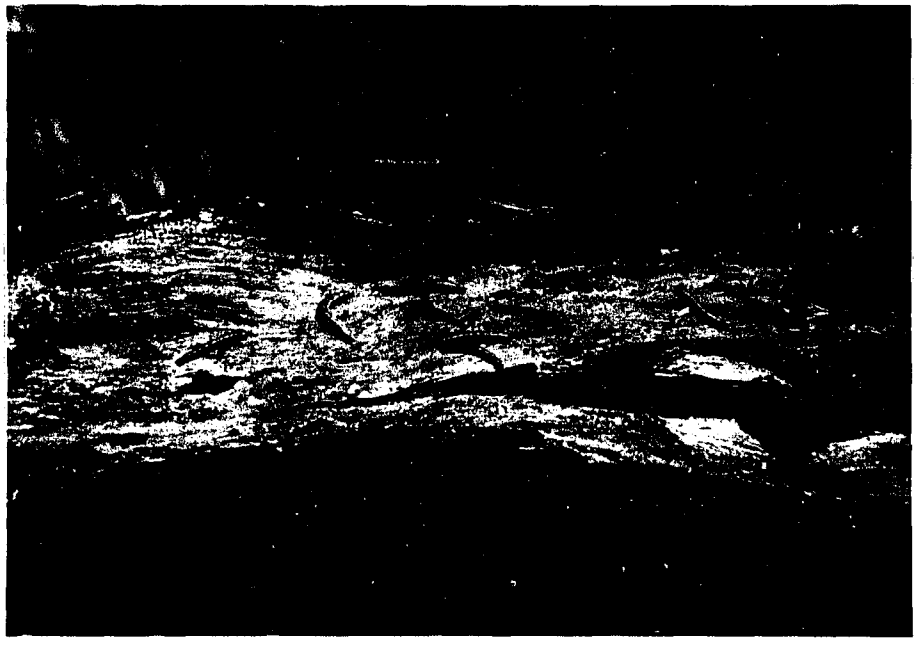


Figure 16. Caterpillar larvae of Melipotis ochrodes on bark of mesquite, southwestern Puerto Rico, 1987.

Table 3.[1] Incidence of caterpillars or pupae in the stomachs of 7 Shiny Cowbirds[1] collected in southwestern Puerto Rico, 18-19 November 1987.

Specimen Number	Species and Number Observed		
	Mocis latipes		*Melioptis ochrodes*
	Caterpillars	Pupae	Caterpillars
1	-	-	-
2	-	-	11
3	-	-	13
4	-	-	9
5	-	-	24
6	-	-	17
7	-	-	26

[1]Specimens courtesy of the Louisiana State University Museum of Natural Science (LSUMNS), Baton Rouge, Louisiana.

Percent caterpillars or pupae present in stomachs= 86%
Percent of larvae or pupae of *Mocis latipes* present in stomachs= 0%
Percent of larvae of *Melipotis ochrodes* present in stomachs= 86%

Table 4. Incidence of caterpillars or pupae in the stomachs of 14 Shiny Cowbirds collected in southwestern Puerto Rico, 31 August- 6 September 1988.

Specimen Number	Species and Number Observed		
	Mocis latipes		*Melioptis ochrodes*
	Caterpillars	Pupae	Caterpillars
1	1	1	-
2	4	2	-
3	5	2	-
4	3	1	-
5	-	1	-
6	-	1	-
7	5	1	-
8	10	-	-
9	-	-	5
10	4	1	-
11	-	1	-
12	-	-	19
13	3	-	-
14	-	1	-

Percent caterpillars or pupae present in stomachs= 100%
Percent of larvae or pupae of *Mocis latipes* present in stomachs= 86%
Percent of larvae of *Melipotis ochrodes* present in stomachs= 14%

Table 5. Incidence of caterpillars or pupae in the stomachs of 38 Greater Antillean Grackles collected in southwestern Puerto Rico, 31 August- 6 September 1988.

Specimen Number	Species and Number Observed			
	Mocis latipes		*Melioptis ochrodes*	Unidentified
	Caterpillars	Pupae	Caterpillars	Caterpillars
1	4	6	-	-
2	-	1	-	-
3	3	-	1	-
4	5	-	-	-
5	-	-	-	-
6	-	-	-	-
7	-	-	-	-
8	8	2	-	-
9	-	-	-	-
10	-	-	4	-
11	-	-	-	-
12	4	-	-	-
13	-	-	-	-
14	-	-	9	-
15	-	-	11	1
16	-	-	30	-
17	-	-	2	-
18	-	-	2	-
19	-	-	20	1
20	-	-	2	-
21	4	-	4	-
22	-	-	15	1
23	26	4	-	-
24	-	-	-	-
25	-	-	14	-
26	-	-	2	-
27	-	-	3	-
28	9	-	22	-
29	-	-	6	-
30	1	-	16	-
31	-	-	5	-

Table 5. Continued.

Specimen Number	Species and Number Observed			
	Mocis latipes		*Melioptis ochrodes*	Unidentified
	Caterpillars	Pupae	Caterpillars	Caterpillars
32	-	-	2	-
33	-	-	8	-
34	-	-	7	-
35	-	-	2	-
36	-	-	2	-
37	-	-	1	-
38	14	-	-	-

Percent caterpillars or pupae present in stomachs= 82%
Percent of larvae or pupae of *Mocis latipes* present in stomachs= 39%
Percent of larvae of *Melipotis ochrodes* present in stomachs= 77%

Mocis latipes by cowbirds and Melipotis ochrodes by grackles, when both caterpillar species were available, may have reflected differences in the accessibility of prey to foraging icterids. Because of their longer bills, grackles were able to probe deeper into crevices and behind the loose bark of mesquite, and were therefore more efficient at foraging on Melipotis ochrodes. Thus, larvae of Melipotis ochrodes were probably more accessible to grackles. This explains the higher percentage of Melipotis ochrodes in the stomachs of grackles in 1988.

Additionally, cowbirds often fed on Melipotis ochrodes when Mocis latipes was unavailable or when Melipotis ochrodes was relatively "more" available. The lack of Mocis latipes in the stomachs of cowbirds collected in 1987 could have been due to the unavailability of Mocis latipes in areas where cowbirds were collected.

Because of its long tap roots (Fisher 1977, Fisher et al. 1959), mesquite had water available to it for longer periods than understory grasses. Consequently, fresh mesquite foliage was available to larvae of Melipotis ochrodes for longer periods and this caterpillar was sometimes available to Shiny Cowbirds when Mocis latipes was absent.

Outbreaks of Mocis latipes, Melipotis ochrodes, and other caterpillars were associated with periods of rainfall. After sufficient amounts of cumulative rainfall, mesquite and grasses sprouted new vegetation, adult moths (Fig. 17) laid eggs on the new vegetation, which hatched within 2-3 days, and within ca. 8-10 days following rains, icterids were observed feeding on caterpillars. Icterids foraged on caterpillars as long as caterpillars were available. Rain in excess of 76.2 mm was often sufficient to provide ample vegetation

Figure 17. Adult male moth of Mocis latipes, southwestern Puerto Rico, 1988.

for more than one generation of moths. Subsequent to the 38.86 mm of rain of 24-30 May and the 99.06 mm of rain during 31 May-6 June (Fig. 8; App. E), vegetation was available to Mocis latipes for almost a month and resulted in successive outbreaks of caterpillars of this moth. Consequently, Shiny Cowbirds and other icterids were observed foraging primarily on caterpillars during 7-13, 14-20, and 21-27 June (Fig. 8; App. D). An additional 122.43 mm of rain on the study area during 21-27 June (Fig. 9; App. E), provided sufficient moisture for grasses to sprout new foliage and provide additional vegetation to Mocis latipes. New outbreaks of these caterpillars resulted in further observations of Shiny Cowbirds and other icterids foraging on caterpillars through 19-25 July.

Additionally, grazing intensities and agricultural practices influenced the availablility of Mocis latipes that foraged on grasses. Under light to moderate grazing (Fig. 11), grass vegetation was available to foraging caterpillars for longer periods than when areas were subject to heavier grazing (Fig. 12). Under intense grazing, larvae of Mocis latipes competed with cattle for available vegetation. Rainfall in excess of 76.2 mm would stimulate new growth of grasses sufficient for an initial generation of Mocis latipes. However, on heavily grazed areas cattle quickly removed the foliage and there was insufficient food for Mocis latipes to rear successive generations.

In areas where grazing was lighter, however, there was often enough vegetation for Mocis latipes to rear an additional generation of moths. Under such conditions, Shiny Cowbirds often concentrated in large flocks (Table 2) with other icterids to forage on successive

generations of available caterpillars. For example, cumulative rainfall of 76.71 mm during 16-22, 23-29 August, and 30 August-5 September (Fig. 9; App. E) prompted an outbreak of Mocis latipes on Cenchrus ciliaris northwest of the Pitahaya Roosts. Consequently, Shiny Cowbirds were observed foraging on the larvae of Mocis latipes beginning in the 13-19 September period (Fig. 8; App. D). An additional 84.07 mm of rain during 13-19 and 20-26 September (Fig. 9; App. E), stimulated additional vegetative growth sufficient for successive generations of Mocis latipes and provided food to cowbirds and other icterids through 11-17 October (Fig. 9; App. E). By 18 October, however, caterpillars were available to Shiny Cowbirds and other icterids only on the east side of Pitahaya Road where grazing was lighter. Consequently, icterids concentrated in this area 18-20 October to forage on the remaining caterpillars. On 18 October, I observed two large, mixed-species flocks of icterids, foraging on larvae of Mocis latipes. One flock contained about 200 Yellow-shouldered Blackbirds, and about 2000 Greater Antillean Grackles. The second flock was located about 600 m east of the first flock and contained an estimated 100 Yellow-shoulderd Blackbirds, 1000 Greater Antillean Grackles, and 50 Shiny Cowbirds (Table 2, McKenzie and Noble 1989). On 20 October, similar flocks were observed at the same locations except that the second flock had an estimated 600 Shiny Cowbirds (Table 2, McKenzie and Noble 1989). Concentrations of icterids on the study area in 1987 often contained large numbers of marked cowbirds. Within the large mixed-species flocks of icterids foraging on caterpillars on 21 September, 24 September, 12 October, and

20 October, 1987, were a minimum of 112, 101, 69, and 65 marked cowbirds, respectively. As caterpillar numbers became reduced over time, cowbirds and other icterids often tore open chrysalises (Fig. 18) to feed on pupae (Fig. 19) of Mocis latipes.

Mesquite is an important source of charcoal and fence posts in southwestern Puerto Rico. Farmers often trim back mesquite by removing branches suitable for posts and charcoal. Smaller branches are trimmed and left on the ground as debris. As the branches of mesquite are armed with thorns, cattle are reluctant to graze on grasses protruding from such debris on the ground. The additional grass vegetation protected by mesquite debris provided food for Mocis latipes. Cowbirds often used mesquite debris as perches to reach caterpillars on grass emerging from the brush piles.

Although Shiny Cowbirds were not commonly observed in open fields (Fig. 7; App. C), I observed cowbirds in an open field after an outbreak of Mocis latipes on Cenchrus ciliaris during 13-19 September. The occurrence of Mocis latipes in this field may have been related to its proximity to an adjacent, irrigated agricultural field. The Cenchrus ciliaris adjacent to the irrigated field apparently had enough soil moisture to provide vegetation for Mocis latipes, even though grasses in the surrounding mesquite woodland were under drought conditions.

What host plant Mocis latipes foraged on appeared to be dependent on the location. Cenchrus ciliaris and Panicum maximum were the main hosts in mesquite woodland on the proposed VOA site, the Cabo Rojo National Wildlife Refuge, and areas northeast of the Pitahaya Roosts

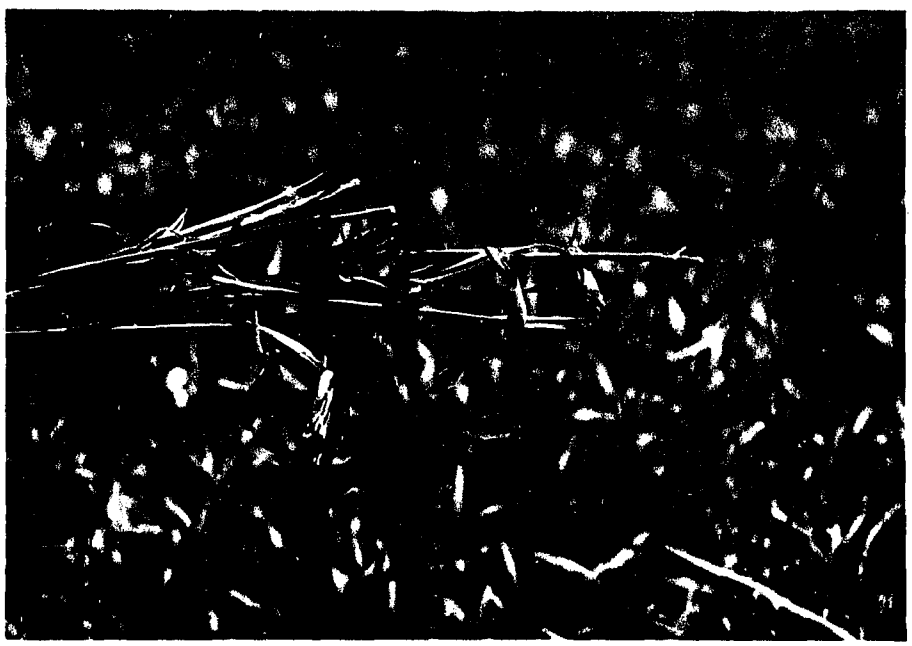


Figure 18. Chrysalises of Mocis latipes encased in blades and culms of Cenchrus ciliaris, southwestern Puerto Rico, 1988.

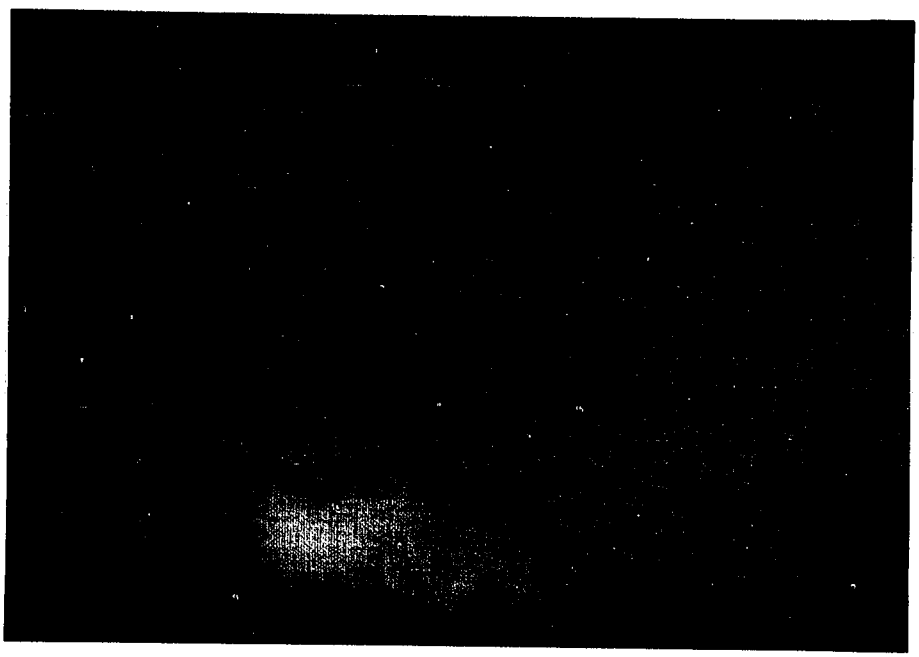


Figure 19. Pupae of Mocis latipes, southwestern Puerto Rico, 1988.

(Fig 6.). In areas adjacent to the coast, Mocis latipes foraged on Chloris inflata, Sprorbolus pyramidatus or Cynodon dactylon. Adjacent to the DNR refuge, Mocis latipes' main host plants were Bothriochloa pertusa and Cenchrus ciliaris. Near La Parguera, Bothriochloa pertusa and Panicum maximum were the major hosts for Mocis latipes.

Under the proper conditions, outbreaks of Mocis latipes in southwestern Puerto Rico can be extensive. Severe outbreaks of Mocis latipes on Cenchrus ciliaris and Panicum maximum in southwestern Puerto Rico have been well documented (Maldonado-Capriles and Colon-Ferrer 1973). During such outbreaks, caterpillars can be so abundant that they completely strip the vegetation from host plants (Figs. 20, 21).

The periodic caterpillar outbreaks of Mocis latipes in southwestern Puerto Rico are probably related to changes in the availability of host plants associated with mesquite woodland and agricultural crops. Mesquite and many of the understory grasses associated with this habitat are not native to Puerto Rico (Liogier and Martorell 1982, Little and Wadsworth 1989). Mesquite was introduced to Puerto Rico around 1600 to provide lumber for railroad ties and quickly spread in savannas, pastures, and abandoned agricultural fields (Little and Wadsworth 1989). Most of the grasses associated with mesquite woodland were introduced as forage grasses (Liogier and Martorell 1982). Although Panicum maximum has been common in southwestern Puerto Rico for at least 100 years (Roberts 1948), other forage grasses such as Bothriochloa pertusa, Cenchrus ciliaris, and Dichanthium annulatum have only been common in this region for about 50 years (Alberts and Garcia-Molinari 1943, Garcia-Molinari 1952, Liogier and Martorell

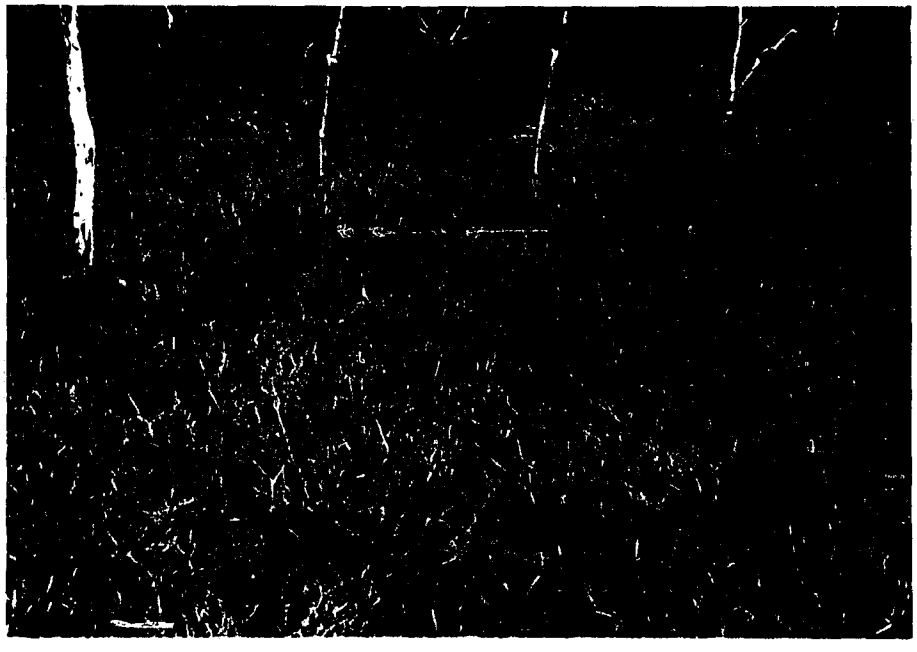


Figure 20. Caterpillar destruction of Mocis latipes on Cenchrus ciliaris, southwestern Puerto Rico, 1987.

Figure 21. Caterpillar destruction of Mocis latipes on Panicum maximum, southwestern Puerto Rico, 1987.

1982). These grasses are now abundant in southwestern Puerto Rico and are all hosts for Mocis latipes (Martorell 1975, pers. obs.). Additionally, cereal grasses such as sugar cane [a known host for Mocis latipes in Puerto Rico (Jones and Wolcott 1922)], have been common on the islands for at least 250 years. With an abundance of host plants, conditions have been favorable for population explosions of this caterpillar. Such outbreaks of Mocis latipes on these grasses have been well documented in southwestern Puerto Rico (e.g., Maldonado-Capriles and Colon-Ferrer 1973).

It is probable that icterids in southwestern Puerto Rico have adapted to the periodic infestations of caterpillars associated with mesquite woodland and agricultural crops. Records of predation on such caterpillars by icterids in this region of the island have been documented since the early 1900's (e.g., Jones 1913, Van Dine 1913, Jones and Wolcott 1922).

Shiny Cowbirds also foraged on the fruit of certain shrubs and grasses (Fig. 8; App. D). Fruits of Cordia globosa var. humilis and Tournefortia volubilis (Fig. 22), were the most frequently observed taken by Shiny Cowbirds (Table 1). Berries of Cordia globosa var. humilis appeared to be a preferred food when available. During the 28 June-4 July period, berries of this shrub accounted for 42% of foraging observations (Fig. 8; App. D), even though larvae of Mocis latipes and Melipotis ochrodes were available. Shiny Cowbirds were observed most frequently feeding on the seeds of the grasses Brachiaria subquadriparia and Panicum maximum (Table 1, Fig. 23). Seeds of Brachiaria subquadriparia were available to cowbirds during 12-18 July

Figure 22. Berries of Tournefortia volubilis, southwestern Puerto Rico, 1987.

Figure 23. Panicum maximum with inflorescences, southwestern Puerto Rico, 1987.

through 9-15 August, while those of Panicum maximum were available during 20-26 September, 11-17 and 18-24 October, and 1-7 November.

When drought conditions existed, and when caterpillars, berries, or seeds were no longer available, Shiny Cowbirds concentrated in residential or agricultural areas (Fig. 1) (e.g., at chicken pens adjacent to the Cabo Rojo National Wildlife Refuge, or the Boqueron Dairy), where they foraged on such food sources as waste corn or other grain (Figs. 7, 8; App. C, D). Additionally, during drought periods, cowbirds foraged on the flowers and foliage of mesquite (Fig. 8; App. D).

Little information on the habitat use, movements, and foraging behavior of Shiny Cowbirds can be found in the literature. Post and Wiley (1977a) indicated that Yellow-shouldered Blackbirds and Shiny Cowbirds fed in mixed-species flocks "around cattle feeding lots, monkey feeders and pasture." In the Dominican Republic, Arendt and Vargas-Mora (1984) reported that Shiny Cowbirds fed on rice and grains, and were often observed in disturbed areas, at or near rice fields, pasturelands, and livestock management facilities.

Shiny Cowbirds are apparently opportunistic feeders as are other cowbirds. White et al. (1985) reported that the diet of Brown-headed Cowbirds (Molothrus ater) contained 74% weed seeds taken primarily in pastures and 22% corn taken from livestock feedlots. Dolbier et al. (1978) assessed the impact of blackbirds on agricultural crops and found that Brown-headed Cowbirds were usually associated with cattle and that corn (54%) and weed seeds (34%) were their major foods.

I could find no references that reported Shiny Cowbirds foraging

on caterpillars. However, previous authors have discussed icterids foraging on caterpillars in Puerto Rico. Post (1981) observed Yellow-shoudered Blackbirds feeding their young and indicated that larvae of Melipotis sp. were a common food item. Post further stated, "larvae of these moths feed in the tree canopy at night and during the day move down the trunk to hide in crevices in the bark, which is also screened by surrounding shrubs." Although Post did not identify the host plant for the Melipotis sp. he observed, his discussion suggests that mesquite was the host plant and Melipotis ochrodes was the species of caterpillar involved; a species that I observed icterids frequently foraging on in this study. Van Dine (1913) indicated that Greater Antillean Grackles and Smooth-billed Anis (Crotophaga ani) foraged on larvae of Mocis latipes "especially in the more open grass lands." Jones (1913) reported that grackles and anis "undoubtedly" did "a great deal of good in reducing the numbers of caterpillars, particularly those occurring in the more open grasslands."

Observations of Shiny Cowbirds foraging on the leaflets and inflorescences of mesquite during periods of drought, while unusual for granivorous or insectivorous passerines, is not however, unprecedented. Bazely (1987) reported that Snow Buntings (Plectrophenax nivalis) foraged on newly grown leaves of salt-marsh grass (Puccinellia phryganodes Scribn. and Morr.) at Manitoba, Canada during the spring. Bazely (1987) suggested that the leaves of the grass were high in nitrogen, were possibly rich in other nutrients, and perhaps an important food source for buntings during spring migration. Dunham (1966) reported that part of the diet of Rose-breasted Grosbeaks

(Pheucticus ludovicianus) in New York included the "buds, flower, fruits, and/or young leaves of various trees and shrubs." In the present instance, the leaves and inflorescences of mesquite may be of sufficient nutritional value to supplement a cowbird's diet during periods of drought when preferred food items are scarce.

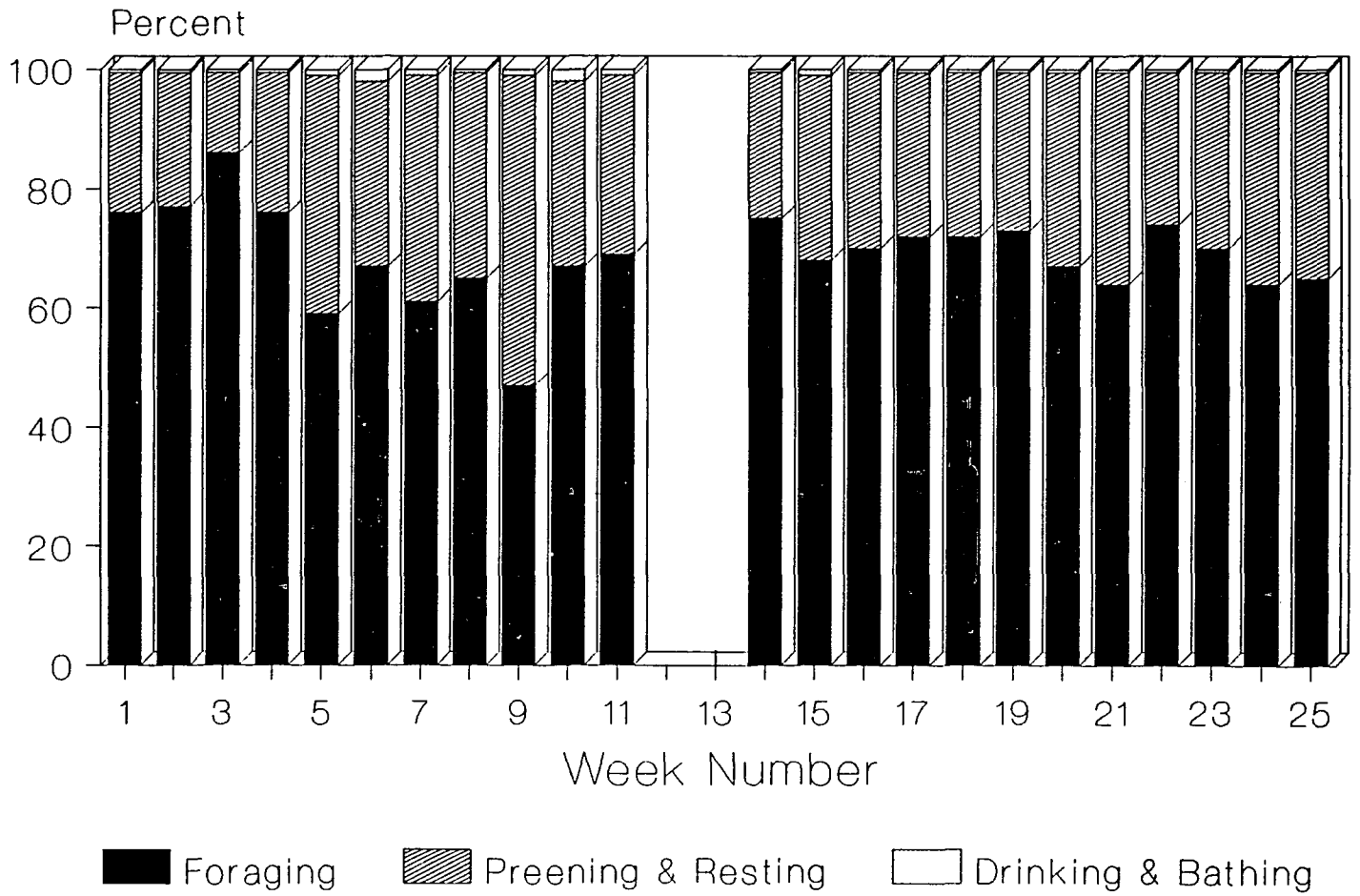
Activity Budgets

On average, Shiny Cowbird flocks spent approximately 68% of the time foraging (range= 47 to 86), 31% of the time resting and preening (range= 14 to 52), and about 1% of the time drinking and/or bathing (Fig. 24; App. F). Shiny Cowbirds spent more time preening and resting than foraging only during the 26 July-1 Aug. period (Fig. 24; App. F).

The time Shiny Cowbirds spent foraging, resting and preening, or bathing and drinking, was comparable to the results reported for other larger passerines. Brown Thrashers (Toxostoma rufum) spent about 47% and 46% of their time foraging and resting/preening, respectively, during the winter in coastal Texas (calculated from Fischer 1981). Verbeek (1972) recorded the annual time budgets of the Yellow-billed Magpie (Pica nuttalli) in percent for the following activities: foraging= 56%, resting and preening= 34%, and bathing and drinking= 1.5%. Lundberg (1985) found that European Starlings (Sturnus vulgaris) spent "a major fraction" of their time foraging and resting, but noted that the time occupied in these activities showed a pronounced seasonal variation.

The less time cowbirds spent foraging during the 26 July-1 August period may have been due to random chance or seasonal differences in nutritional requirements. Puttick (1979) indicated that the time Curlew Sandpipers (Calidris ferruginea) foraged ranged from 53% in November to 85% in April (av.= 69%). Puttick (1979) attributed these differences to "spatial and temporal variations in the seasonal availability of food to Curlew Sandpipers, together with seasonal variations in the birds' energy requirements.

Figure 24. Activity budgets for Shiny Cowbirds, by weekly period, southwestern Puerto Rico, 1987 (n= 50,597 minutes; ca. 843 hrs.).


Percent
100
80
60
40
20
0
1
3
5
7
9
11
13
15
17
19
21
23
25
Week Number
Foraging
Preening & Resting
Drinking & Bathing

Allopreening

Nine incidences of allopreening (described as an invitation to preen by some) were observed between Shiny Cowbirds and Yellow-shouldered Blackbirds (Table 6). Four observations involved 4 marked males and 5 observations involved 3 marked females (Table 6). The invitation to preen was usually done in the following manner: 1) a cowbird would fly or hop to the same branch where a blackbird was perched, 2) with its head bowed down in the typical "head-down" (Selander and LaRue 1961) display and with its body somewhat lowered, the cowbird would gradually crawl along the branch until it was next to the blackbird, 3) the cowbird would then further present its nape to the blackbird while lowering its head a few more degrees and remain motionless. Blackbirds usually accepted the invitation (at least between marked cowbirds and blackbirds: see Table 10) and began preening a displaying cowbird. On a few occasions, however, I watched a blackird would move a few centimeters away from the cowbird. In such cases, cowbirds would quickly creep along the branch until again next to the blackbird and repeat the invitation. In three instances that involved unmarked cowbirds (Table 6), blackbirds rejected the invitation by either flying off or pecking at the cowbird. When the invitation to preen was successful, blackbirds allopreened cowbirds an average of 1 minute (Table 6).

Allopreening has been recorded in at least 43 avian families (Harrison 1965, 1969, Sparks 1965, Forsman and Wright 1979), and although the behavior has been reported for five of six species of cowbirds and other icterids (Chapman 1928, Harrison 1963, Selander

Table 6. Incidence and outcome of allopreening (invitations to preen) between marked and unmarked Shiny Cowbirds and Yellow-shouldered Blackbirds, southwestern Puerto Rico, 1987-1988 (n= 15).

Date	Tag Number	Sex	Outcome of Invitation	Number of Minutes Preened
1987				
7 July	B 21	M	Successful	1
5 Aug.	B 36	M	Successful	1
18 Oct.	Unmarked	F	Successful	1
18 Oct.	Unmarked	F	Rejected	-
20 Oct.	B 35	M	Successful	1
20 Oct.	C 17	F	Successful	1
24 Oct.	Unmarked	F	Rejected	-
24 Oct.	Unmarked	F	Rejected	-
24 Oct.	A 37	F	Successful	1
12 Nov.	B 37	F	Successful	1
12 Nov.	B 37	F	Successful	2
12 Nov.	B 37	F	Successful	1
23 Nov.	B 70	M	Successful	2
1988				
27 Aug.	Unmarked	F	Successful	1
31 Aug.	Unmarked	F	Successful	5

1964, Dow 1968, Payne 1969, Verbeek et al. 1981), few observations under natural conditions have been noted between Shiny Cowbirds and potential hosts. Selander (1964) reported that captive male and female Shiny Cowbirds solicited allopreening from a House Sparrow (Passer domesticus) and indicated that the "head-down invitation display" of this species was similar to that of Brown-headed and Bronzed Cowbird (Molothrus aeneus).

To my knowledge, my observations of allopreening between Shiny Cowbirds and Yellow-shouldered Blackbirds are the first documented records. Although the interactions between Shiny Cowbirds and Yellow-shouldered Blackbirds have been extensively studied (Post and Wiley 1976, 1977a,b, Post 1981, Cruz et al. 1985, Wiley 1985a,b, Post and Post 1987), I can find no published report of the head-down display or subsequent allopreening between the two species.

There is apparently no agreement on the adaptive significance of allopreening. Because Dow (1968) believed that there were few records of allopreening by Brown-headed Cowbirds observed outside the aviary, he questioned whether the behavior had any "biological significance." Dow (1968) added, however, that there was a possibility that "we are observing the initial stages of a behavioral adaptation in a very recently evolved brood parasite."

Many still agree with the assessment of Selander and LaRue (1961) who suggested that allopreening "results in reduced hostile tendencies of individual birds that are potential hosts for the cowbird." Although Harrison (1965) and Fitzpatrick (1975) suggested that allopreening in owls was important as a means of sexual or individual

recognition, Forsman and Wright (1979) concluded that this behavior was a "peaceful interaction without agressive overtone." Selander (1964) rejected Friedman's (1963) hypothesis that the allopreening behavior in cowbirds was a "memory induced reaction based on early experience of care by adults of other species." Although the Bay-winged Cowbird (Molothrus badius) is not a brood parasite (Friedmann 1929), it has elicited preening invitations from Chestnut-fronted Troupials (Agelaius ruficapillus) and House Sparrows (Selander 1964). Selander (1964) suggested that such behavior by a non-parasitic cowbird was evidence that the "preening invitation behavior did not evolve in cowbirds specifically as adaptation for brood parsitisim." Scott and Grumstrup-Scott (1983) supported Selander's (1964) hypothesis and added that the head-down display associated with allopreening "may not have evolved in a direct relationship with brood parasitism," but "may have evolved before the habit of brood parasitism." Harrsion (1965) postulated that allopreening evolved as a ritualized form of agressive pecking or biting behavior. Scott and Grumstrup-Scott (1983) disagreed with Rothstein's (1971, 1980) suggestions that the head-down display was agressive in nature or was an example of behavioral mimicry.

In their analysis of the head-down display associated with allopreening, Scott and Grumstrup-Scott (1983) proposed the following "consolidated hypothesis"-- "The head-down display is an appeasing, agonistic behavior that reduces agonistic behaviors of the recipient toward the displaying cowbird. The displayor is generally dominant to the recipient, and preening is a stimulus for subsequent displaying by the preened cowbird. The display functions in obtaining food,

minimizing roosting energetics, and/or establishing flock order." Regarding the foraging benefits that cowbirds could realize in mixed-species flocks, the same authors further postulated that "the head-down display may facilitate a cowbird's joining a foraging group by appeasing flock members or by helping to assess agonistic tendencies of flock members." They also suggested that cowbirds using the display might enable roosting birds to establish positions in communal roosts and that such positions would help cowbirds minimize overnight energy expenditures necessary for thermoregulation.

Goodwin (1983) postulated that allopreening could serve a role in removing ectoparasites and Brooke (1985) attributed the differences in tick loads between paired and unpaired Macaroni (Eudyptes chrysolophus) and Rockhopper (Eudyptes chrysocome) Penguins to allopreening. Because allopreening is often associated with individuals that are forced into close proximity to one another (Cullen and Ashmole 1963, Harrison 1965), Brooke (1985) believed that "such conditions facilitate transfer of ectoparsites from one individual to another," and suggested that "allopreening initially evolved because it uniquely combined cleansing and social functions." Other reseachers have supported the theory that the behavior serves a sexual or social purpose (Simmons 1967, Gaston 1977).

The function of allopreening between Shiny Cowbirds and Yellow-shouldered Blackbirds is not clear and the above hypotheses can only partially explain the purpose of the behavior for the the following reasons. First, although I commonly observed Yellow-shouldered Blackbirds foraging, resting, preening, drinking and bathing

with Greater Antillean Grackles as well as Shiny Cowbirds, I never observed allopreening between cowbirds and grackles. Shiny Cowbirds parasitize the nests of Greater Antillean Grackles as well as blackbirds (Cruz et al. 1985, Wiley 1985b). If allopreening was an adaptation for brood parasitism as hypothesized by Scott and Grumstrup-Scott (1983), then I should have noted the behavior between cowbirds and grackles as well as between cowbirds and blackbirds. Thus, if the head-down display serves as an appeasement display to reduce "hostile tendencies of individual birds that are potential hosts" (Selander and LaRue 1961), the behavior should be in operation between cowbirds and grackles as well.

Some have suggested that head-down displays of cowbirds are seldom directed toward common hosts (Friedmann 1929, 1963, Hicks 1934, Rothstein 1980, Scott and Grumstrup-Scott 1983). Although Greater Antillean Grackles are currently more common in southwestern Puerto Rico than Yellow-shouldered Blackbirds, I do not think that this is the main reason for the lack of observations of this behavior between grackles and cowbirds. One possibility is that the much larger grackles are dominant to cowbirds and thus pose a threat to them. Scott and Grumstrup-Scott (1983) suggest that for the head-down display to serve as an appeasement display, the displayor should be dominant to the recipient. If so, and if Shiny Cowbirds are subordinate to Greater Antillean Grackles, the behavior may be non-operative between the two species. Rothstein (1980) indicated that "the display is an agressively motivated gesture that cowbirds use in a variey of contexts to assess fighting potential of other birds, ... to establish dominance."

The lack of the behavior between cowbirds and grackles may indicate that dominance is already established and that cowbirds are only able to solicit invitations to preening from subordinate blackbirds.

As I observed the behavior between cowbirds and blackbirds and not cowbirds and grackles, it may be related to differences in parasitism rates between the two hosts. Cruz et al. (1985) noted that while 94.2% of the nests of Yellow-shouldered Blackbirds they studied were parasitized by cowbirds, only 9.9% of grackle nests were parasitized. Similarly, Wiley (1985b) reported parasitism rates of 95% and 11% by cowbirds on the nests of blackbirds and grackles, respectively. These differences in parasitism rates may suggest that grackles have been in less contact with cowbirds and that the behavior is not well developed between the two species.

I do not believe that allopreening between cowbirds and blackbirds functions in "minimizing roosting energetics" as suggested by Scott and Grumsptrup-Scott (1983). The center of abundance for five of six species of cowbirds are concentrated in tropical and semi-tropical regions where overnight expenditure for thermoregulation is not as important as for Brown-headed cowbirds that occur in temperate North America.

Because Shiny Cowbirds frequently forage in mixed-species flocks with Yellow-shouldered Blackbirds and Greater Antillean Grackles, it is possible that the head-down display associated with allopreening between cowbirds and blackbirds is important in establishing and maintaining flock order as suggested by Rothstein (1980) and Scott and Grumstrup-Scott (1983) or in reducing agression between flock members

when feeding. Ng and Jasperson (1984) indicated that the head-down display and subsequent allopreening between Crested Caracara and Black Vulture may have allowed displaying caracaras to join Black Vultures for foraging and roosting. Ng and Jasperson (1984) also stated that "the advantages of the display in allowing a cowbird to join a flock for foraging and roosting may apply equally to the caracara." Thus, as indicated by Gaston (1977), allopreening between Shiny Cowbirds and Yellow-shouldered Blackbirds may serve a social function and be important in preventing flock disorganization.

Sunning

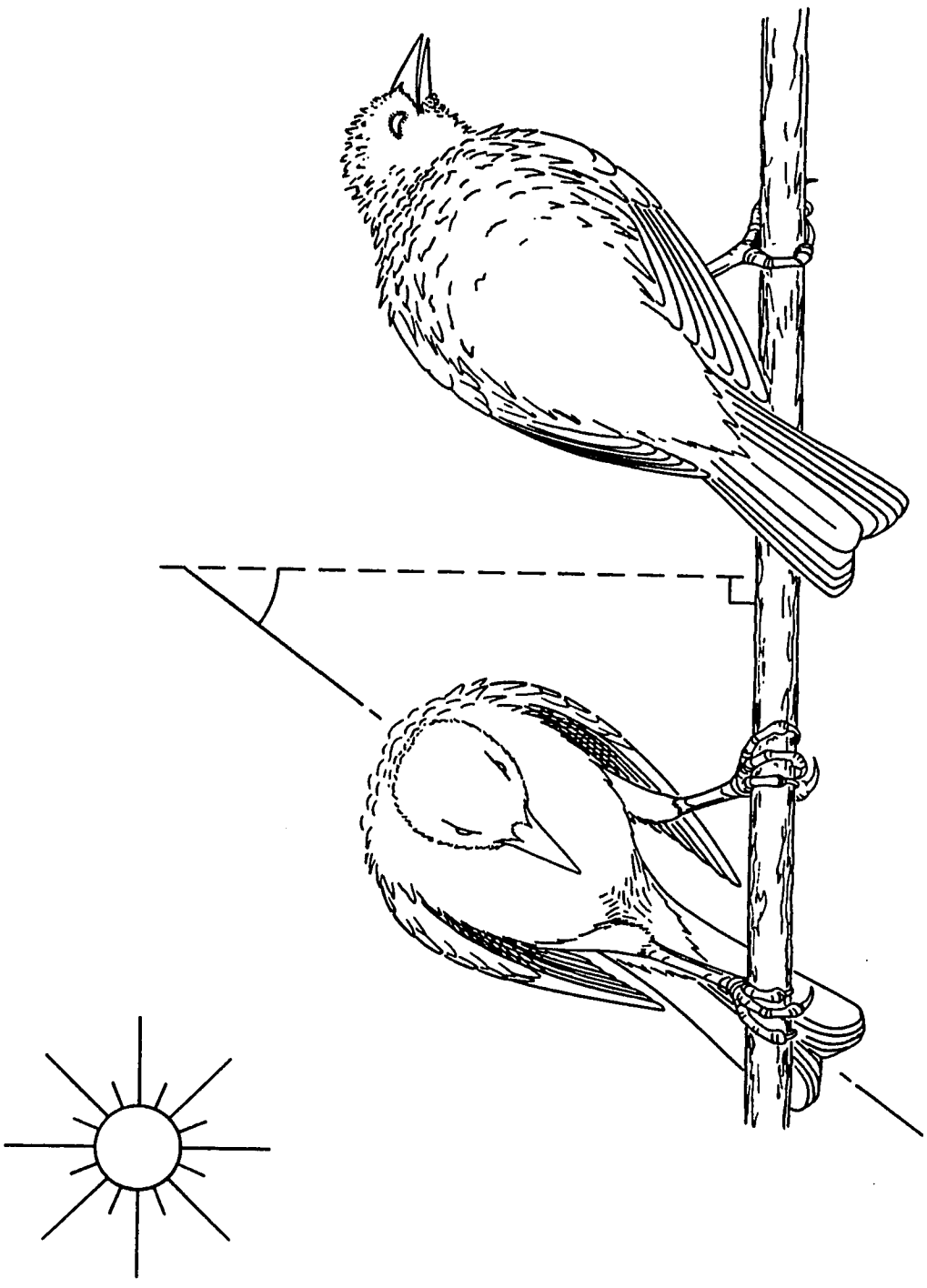
Shiny Cowbirds were observed 25 times sunning or sunbathing in the "lateral sunning posture" as described by Simmons (1986:36-46) (Table 7). In this behavior, birds would suddenly stop a particular activity, tilt their head and body at approximately a 35-40 degree angle towards the sun, hold open their bill, and fluff out their feathers (Fig. 25). Sunning sometimes involved multiple individuals and usually lasted between 1 and 4 minutes (average 1.3 minutes, see Table 7). The same behavior was observed on 2 occasions with Greater Antillean Grackles (Quiscalus niger) and Troupials (Icterus icterus) (Table 7).

The adaptive significance of sun bathing or sunning in birds has long been debated. Simmons (1986:4-9) reviewed and discussed the different aspects of the thermoregulatory functions of sunning. Some have suggested that sunning serves either as a heat dissipation (Hauser 1957, Kennedy 1969) or heat absorption (Brown and Amadon 1968) mechanism. Lanyon (1958) stated that he regarded "a sudden warming of

Table 7. Incidence of sunning using the "lateral posture" (Simmons 1986) by icterids, southwestern Puerto Rico, 1987 (n= 28).

Date	Species	Number of birds Participating In the activity	Minutes Observed
1987			
4 Sep.	Shiny Cowbird	11	4
6 Sep.	Shiny Cowbird	2	1
6 Sep.	Shiny Cowbird	1	1
6 Sep.	Shiny Cowbird	5	2
6 Sep.	Shiny Cowbird	1	1
8 Sep.	Shiny Cowbird	1	1
8 Sep.	Shiny Cowbird	1	1
11 Sep.	Shiny Cowbird	1	1
11 Sep.	Shiny Cowbird	1	1
11 Sep.	Shiny Cowbird	4	1
11 Sep.	Greater Antillean Grackle	1	1
12 Sep.	Shiny Cowbird	1	1
12 Sep.	Shiny Cowbird	1	1
14 Sep.	Shiny Cowbird	1	1
14 Sep.	Shiny Cowbird	1	2
15 Sep.	Troupial	1	1
16 Sep.	Shiny Cowbird	2	1
16 Sep.	Shiny Cowbird	1	1
25 Sep.	Shiny Cowbird	1	1
5 Oct.	Greater Antillean Grackle	2	1
6 Oct.	Shiny Cowbird	1	1
14 Oct.	Shiny Cowbird	1	1
14 Oct.	Shiny Cowbird	1	1
7 Nov.	Shiny Cowbird	2	2
14 Nov.	Shiny Cowbird	1	1
19 Nov.	Shiny Cowbird	1	1
14 Dec.	Shiny Cowbird	1	3
1988			
31 Aug.	Shiny Cowbird	3	2

Figure 25. Sunning behavior by Shiny Cowbirds using the "lateral posture," (Simmons 1986) southwestern Puerto Rico, 1987-1988.



the bird's immediate environment as being extremely important in the motivation of sun-bathing behavior." Because birds often sunbathed during the hottest times of the day and the hottest times of the year (Hauser 1957, Teager 1967), Mueller (1972) theorized that "heat conservation was probably not a benefit of sunning."

Because sunbathing behavior has been reported to be more frequent during the time of the molt than other periods of the year (Hauser 1957), and because anting apparently occurs most often during the time of molt (Potter 1970, Potter and Hauser 1974), some researchers have suggested that the two behaviors serve similar functions. Rothschild and Clay (1952) asserted that anting has its "phyletic origins in sunbathing," because "both anting and sunbathing are followed by vigorous and extended preening." Hauser (1973) observed birds sunning in conjunction with anting. Potter and Hauser (1974) reviewed the significance of anting and sunning and concluded that "the correlation of sunbathing with head and upper body molt offers a more logical explanation, particularly in view of the apparently complimentary relationship of anting to the moulting of wing and tail feathers." They further stated that sunning and anting were "complimentary, comfort-motivated behaviors" and the means birds used were dependent "upon the location of the feather tract(s) currently in molt." Based on Potter and Hauser's (1974) analysis, birds would apparently "prefer" sunning to anting if molting feather tracts were easily exposed to sunlight. Anting on the other hand would be preferred to sunning if molting feather tracts were not sufficiently exposed to sunlight or when molting areas were easily reached with an ant held in the bird's

beak. Potter and Hauser (1974) also observed a Gray Catbird (Dumetella carolinensis) pick up ants, but rather than anting, the bird assumed a sunning position while standing in full shade. These authors suggested that this was evidence supporting the view that the impulses to ant and sunbathe have a common origin. Kennedy (1969) indicated that sunning would increase preen gland secretion, and thus the behavior would be associated with feather care. Thus, Potter and Hauser (1974) agreed with Harrison (1946), Gibb (1947), Hauser (1957), Kennedy (1969), and Burton's (1985) assertion that sunbathing was a maintenance behavior that served a role in molting.

Simmons (1986:97), on the other hand, did not believe that sunning and anting were complimentary activites and also stated that "although sunning birds are sometimes in molt and the effects of sunning could perhaps be of some benefit to that state, any correlation between sunning and moulting may well be only seasonally coincidental, as in the case of anting and moulting."

Simmons (1986:2) recognized two adaptive types of sunning: 1) "sun-basking," which he defined as "a means of absorbing heat and hence a form of thermoregulation," and 2) "sun-exposure (or sunning proper)," which Simmons indicated "probably functions in feather maintenance and related ways, and hence is a form of comfort behaviour."

Regarding the purpose of sunning behavior other than sun-basking, Simmons (1986:101) stated that it served as an "uncertain function but probably a form of feather-maintenance as well as serving other purposes, for example the synthesis of Vitamin-D." Others have also hypothesized that sunbathing promoted the synthesis of vitamin D

(Prosser and Brown 1961, Weisbrod 1971).

Based on the behavior and sunning posture of birds in relation to the sun's position, Hauser (1957) recognized four "levels" of sunning in passerines. Hauser (1957) described the third level as a "full sun" position in which sunning birds leaned to one side, opened their bill and stared at the sun with their upper eye. Simmons (1986:30) attempted a more comprehensive classification of sunning behavior and designated five levels: 1) simple sunning behaviour, 2) the wings-down posture, 3) lateral postures, 4) raised-wing postures, and 5) spread-wing postures. The lateral posture discussed by Simmons (1986) is analagous to Hauser's (1957) full sun position and is most commonly observed in passerines. In addition to my observations of sunbathing by Shiny Cowbirds, Greater Antillean Grackles, and Troupials (Table 7), no less than 24 species of birds have been observed using the lateral sunning position (see review in Simmons 1986: 38-39).

Possibly the function of sunning by Shiny Cowbirds can be inferred from the dates of sunbathing observations. Over 70% of my observations of sunning behavior were between 31 August and 25 September (Table 7). In 1987 I continued to capture, mark, and release cowbirds during this period, and in the process of handling the birds, I noted that they were in various stages of molt. Although I spent hours observing Shiny Cowbirds in 1987 between May and the first observation of sunning on 4 September, I never observed the species sunbathe prior to that date. Additionally, I did not observe captured birds in molt until late August 1987. In 1988, although I did not capture and mark cowbirds, I observed the sunning behavior on 31 August. Thus, I do not think

that the timing of the observations of sunbathing and molting with Shiny Cowbirds were merely coincidental. Although sunning may serve more than one function for other species under different circumstances elsewhere, this behavior probably assists with feather maintenance associated with molt in Shiny Cowbirds in southwestern Puerto Rico. Perhaps sunning assists in the molt process by warming feather sheaths and enabling worn feathers to be more easily displaced by emerging, new feathers.

Cowbird Flocks and Association With Other Icterids

The congregation of Shiny Cowbirds, Greater Antillean Grackles, and Yellow-shouldered Blackbirds in large flocks at caterpillar outbreaks in southwestern Puerto Rico may indicate that these species benefit from social foraging. Many theories have been advocated concerning the adaptive significance of flocking and this topic is discussed in greater detail in the literature review. In the present case, icterids in southwestern Puerto Rico that forage together in large mixed-species flocks possibly benefit from predator protection (Orians 1985, Powell 1985), or increased foraging efficiency by becoming aware of the location of patchy food sources through "local enhancement" (Thorpe 1956:32), "observational learning," (Alcock 1969 a,b) or "imitative foraging" (Greig-Smith 1978). Others have presented theories suggesting that information regarding the location of food concentrations is exchanged between flock members at communal roosts (e.g., information center hypothesis: Ward and Zahavi 1973; assembly point hypothesis: Evans 1982a).

Although I have limited data, my observations of mixed-species flocks of icterids foraging on caterpillars in mesquite woodland may indicate that these species benefit from increased foraging efficiency and predator protection.

While observing flocks of foraging icterids, I often noticed that Greater Antillean Grackles were more successful than either Shiny Cowbirds or Yellow-shouldered Blackbirds in locating caterpillars when caterpillars became first available. Additionally, because of their longer bills, grackles appeared more efficient in locating larvae of

Melipotis ochrodes behind bark and in crevices of mesquite than cowbirds or blackbirds. I observed that grackles were the first members of an icterid flock to locate new caterpillars in grasses and were therefore possibly the leader species in flocks of grackles, cowbirds, and blackbirds. On numerous occasions I watched cowbirds and blackbirds follow behind grackles as grackles searched for caterpillars. When a grackle located a caterpillar, I often observed cowbirds and blackbirds run after grackles in an attempt to steal the prey. Eventually, however, all cowbirds and blackbirds were apparently able to learn how to locate caterpillars by watching grackles. Additionally, I observed immature cowbirds follow adult cowbirds in a similar manner. These observations may support Alcock's (1969 a, b) theory of observational learning or Greig-Smith's hypothesis (1978) of imitative foraging.

In 1988, I observed cowbirds, grackles, and blackbirds foraging on caterpillars at the same locations I observed icterids at in 1987. This may suggest that icterids in southwestern Puerto Rico "learn" or remember the locations of caterpillar outbreaks during different seasons and different years. Because cowbirds, grackles, and blackbirds commonly roost together at communal roosts in southwestern Puerto Rico (Post and Post 1987; pers. obs.), icterids may "learn" the location of caterpillar outbreaks through their associations with one another. If so, this might lend support for Thorpe's (1956:32) theory of "local enhancement," which states that birds learn the location of food sources by seeing groups of foraging individuals at concentrated food patches. Although there is insufficient data to support any of

theories associated with members of bird flocks locating patchy concentrations of food, icterids in southwestern Puerto Rico probably realize a increase in foraging efficiency by participating in such assemblages.

I noted that icterids feeding on caterpillars often foraged on the ground in open to semi-open mesquite woodland. I continually observed icterids flush from the ground, rest for a few minutes, and then return to the ground to forage. I also noted that icterids were extremely wary and often prevented close approach. Such wariness suggested that the birds were constantly on the lookout for predators. Additional information supports the cautious behavior of these birds while foraging. In 1987, I recorded 14 attacks on foraging flocks of icterids in mesquite woodland involving three species of predators: American Kestrel (Falco sparverius), Merlin (Falco americanus), and Small Indian Mongoose (Table 8). Of these, only one attack resulted in the death of one of the members of the flock: a female Shiny Cowbird was killed by an American Kestrel on 20 October 1987 (Table 8). Thus, by foraging in large mixed-species flocks in an open to semi-open habitat, icterids were probably able to better spot potential predators. These observations suggest that predator protection could be a benefit to cowbirds, grackles, and blackbirds that forage together on caterpillars in mesquite woodland. The frequent association of Shiny Cowbirds, Greater Antillean Grackles, and Yellow-shouldered Blackbirds together may also indicate that such flocks may benefit from flock cohesion through social bonding as postulated by Bayer (1982).

Table 8. Incidence and outcome of predator attacks on flocks of foraging icterids, southwestern Puerto Rico 1987.

Date	Predator	Number of Attacks	Outcome
29 June	Small Indian Mongoose	1	Unsuccessful
9 Sep.	Small Indian Mongoose	1	Unsuccessful
29 Sep.	American Kestrel	1	Unsuccessful
1 Oct.	Small Indian Mongoose	1	Unsuccessful
8 Oct.	American Kestrel	1	Unsuccessful
10 Oct.	Merlin	1	Unsuccessful
10 Oct.	American Kestrel	1	Unsuccessful
12 Oct.	American Kestrel	1	Unsuccessful
13 Oct.	Small Indian Mongoose	1	Unsuccessful
20 Oct.	Small Indian Mongoose	1	Unsuccessful
20 Oct.	American Kestrel	1*	Successful
27 Oct.	American Kestrel	3	Unsuccessful

* Unmarked female Shiny Cowbird captured, killed and partly eaten.

Assessement of Patagial Markers

Of the 393 cowbirds marked, 350 (92%) were observed on at least one occasion after their release. Marked cowbirds were observed an average of 11 different days. The minimum number of days tags were retained for 31 males who were subsequently observed with tags ranged from 202 to 707 days; for 16 females the time ranged from 280 to 523 days (Table 9).

Patagial markers were effective in assisting me in monitoring the habitat use and movements of Shiny Cowbirds in southwestern Puerto Rico. Because of their high visibility, patagially marked cowbirds were usually easy to follow and observe, and the markers did not appear to adversely affect the behavior or flight of cowbirds.

The tag retention I recorded for some birds indicates that the technique can be useful for long-term studies. Forty-seven birds were observed to retain their tags a minimum of 202 days, with some tags being retained for up to 707 days (Table 9). Use of the Buttoneer attachment method was helpful in documenting altitudinal migration of Red-winged Blackbirds in Colorado (Cummings 1985). Cummings (1987) reported that 60% of the Common Grackles and 100% of the Red-winged Blackbirds retained their tags in a cage test for 40 weeks using the technique. Further, he concluded that the fasteners had no effect on mortality. Stromborg et al. (1988) used the technique to monitor the survival of European Starling nestlings after fledging that had been dosed with an organophosphorus insecticide. He reported that some of the birds that survived the experiment retained their patagial tags for a minimum of 3 months.

Table 9. Minimum number of days patalgial tags were retained by Shiny Cowbirds, southwesten Puerto Rico, 1987-1989, based on date of tagging or retagging and last date of observation (n= 31 males, 16 females).

Sex	Date tagged Or retagged	Last date of Observation	Minimum number Of days tag Was retained
Male			
B77	9 August 1987	16 July 1989	707
C9	6 May 1987	17 March 1989	681
C19	6 May 1987	24 February 1989	632
C30	20 July 1987	18 November 1988	487
B4	6 May 1987	31 August 1988	482
B34	12 November 1987	3 February 1989	449
B53	6 August 1987	5 October 1988	426
A37	9 August 1987	6 September 1988	401
B70	7 August 1987	6 September 1988	397
B80	12 August 1987	3 September 1988	389
A33	8 August 1987	27 August 1988	386
A35	10 August 1987	27 August 1988	384
B72	7 August 1987	23 August 1988	383
B19	12 November 1987	23 August 1988	382
B35	16 August 1987	1 September 1988	382
B15	6 May 1987	2 May 1988	361
B7	6 May 1987	27 April 1988	356
B25	6 May 1987	19 April 1988	350
B24	6 May 1987	7 April 1988	337
B99	16 August 1987	16 July 1988	335
C3	12 November 1987	11 July 1988	335
B61	7 August 1987	6 July 1988	334
B18	6 May 1987	25 March 1988	324
B92	16 August 1987	29 June 1988	318
B39	29 May 1987	6 April 1988	313
C27	20 July 1987	3 May 1988	288
C29	20 July 1987	13 April 1988	268
B5	6 May 1987	28 January 1988	268
B78	10 August 1987	27 April 1988	261
B37	29 May 1987	2 February 1988	250
B81	12 August 1987	1 March 1988	202
Female			
A1	7 May 1987	11 October 1988	523
A17	7 May 1987	7 September 1988	489
C26	6 May 1987	3 September 1988	486
A33	7 August 1987	17 November 1988	468
B23	29 May 1987	27 August 1988	455

Table 9. Continued.

Sex	Date tagged Or retagged	Last date of Observation	Minimum number Of days tag Was retained
Female			
C16	6 May 1987	31 August 1988	453
B66	7 August 1987	22 October 1988	442
C17	6 May 1987	15 June 1988	406
A44	10 August 1987	7 September 1988	401
B92	12 August 1987	7 September 1988	393
A45	10 August 1987	6 September 1988	392
C49	12 November 1987	1 September 1988	383
B87	12 August 1987	23 August 1988	378
B52	7 August 1987	23 May 1988	290
A38	9 August 1987	23 May 1988	289
B84	12 August 1987	18 May 1988	280

Although tags and tag numbers were easily observed using binoculars or a spotting scope, correctly reading the tag was dependent on the number of characters on the tag and how the tags conformed to the shape of the wing. Some tags bowed around the wrist in the wing while others curled inward on the edges. In both cases, it was often difficult to read more than two characters. How the tag settled on the wing was apparently dependent on the position of the nylon fasteners as fasteners placed too close together caused the edges of the tag to curl.

If fasteners and patalgial markers were correctly placed on the wing, a small attachment loop was visible on the leading edge of the patagium. Because of the potential wear in this area, John Cummings (Research Biologist, Section of Bird Damage Control, USDA, Denver Wildlife Research Center, Building 16, P.O. Box 25266, Denver Federal Center, Denver, CO 80225-0266, pers. commun. 1987) recommended that the attachment strip be cut to reduce friction. I initially cut the strip per Cummings' instructions but noted that this contributed to tag loss for the following reasons. Cutting the attachment strip resulted in 2 separate pieces of fabric. With age, the edges of the smaller piece on the underside of the wing became brittle and curled around the edges of the nylon fastener. Eventually, this area pulled through the patagium and the tag fell from the wing. I did not cut the attachment strip on subsequent markings. Instead, I attempted to prevent abrasion on the leading edge of the patagium by creating more space between the edge of the patagium and the patagial loop attachment strip. This was accomplished by attaching the marker closer to the leading edge of the

patagium. This technique was unsatisfactory, as some fasteners were too close to the edge of the patagium and tore through the skin. Consequently, I further modified the technique by eliminating the space between the attachment loop and the leading edge of the patagium and added an additional fastener. I placed the three fasteners in an evenly spaced triangle. Because recaptured cowbirds with markers attached in this fashion did not show appreciable wear on the patagium, I recommend this procedure for future studies. Cummings (1987) developed the technique I used and reported that Common Grackles and Red-winged Blackbirds had better tag retention when three fasteners were used.

Initially, nylon fasteners were placed so that the round ends of the fasteners were on the facing edge of the wing, while the cross bars were on the underside of the patagium. Subsequent captures of marked cowbirds revealed that the cross bars on the underside of the wing caused irritation in some birds. I modified the technique by placing the round end of the fastener on the underside of the wing.

Although, the Saflag material that I used for construction of patalgial markers proved to be durable, I noted that many tags often became brittle and frayed on the edges after about 12-16 weeks in the field. Although other researchers found Saflag material to be a durable fabric (Bray et al. 1975, 1979; Cummings 1985), I recommend that additional fabrics be tested for wear, especially when long term studies are intended. The marking paint used for lettering and numbering tags was excellent, although the ink faded somewhat after 3 or 4 months. Further modifications to this patalgial marking technique

could increase the longevity and readibility of tags.

CONCLUSIONS

Shiny Cowbirds were located in six major areas of concentration. Of these, all but one were in mesquite woodland; the other area was in littoral woodland. Throughout the study period, Shiny Cowbirds used mesquite woodland almost 75% of the time. Cowbird use of mesquite woodland varied among weekly periods and was linked to rainfall received on the study area during weekly periods prior to a week of observation. Use of mesquite woodland by Shiny Cowbirds was most correlated with rainfall prior to the observation, in particular to the total rainfall 2-5 weeks prior to the observation ($p=0.0067$).

Overall habitat use was ultimately related to food availability. During periods of sufficient rainfall, cowbirds foraged primarily on caterpillars, berries and seeds of various species of grasses. As with use of mesquite woodland, the minutes cowbirds were observed eating caterpillars, berries, or seeds were most correlated with total rainfall 2-5 weeks 2-5 prior to the observation ($p=0.0149$).

Shiny Cowbirds often foraged in mixed-species flocks with Yellow-shouldered Blackbirds and/or Greater Antillean Grackles. When there were at least 50 Shiny Cowbirds in a flock and caterpillars were the major prey item, grackles and blackbirds associated with the flock more so than would be expected by random chance ($p< 0.001$). Shiny Cowbirds, blackbirds and grackles foraged primarily on the larvae of Mocis latipes, Melipotis ochrodes, Spodoptera spp., Melipotis sp., Heliothis sp., and Anticarsia gemmatalis. Mocis latipes, Melipotis ochrodes, and Spodoptera spp.) were the most frequently taken noctuids.

The availability of caterpillars was dependent on the species of moth, the amount of rainfall, the host plant, grazing intensities in areas where outbreaks of grass caterpillars occurred, and agricultural practices. Caterpillars of Mocis latipes and Melipotis ochrodes were the most frequently observed prey taken by Shiny Cowbirds and accounted for 53% and 24% of the observations, respectively. Observational results were supported by 1987 and 1988 stomach analyses. In 1987, 86% of the stomachs of Shiny Cowbirds collected on the study area contained larvae of Melipotis ochrodes. In 1988, 100% of the stomachs of Shiny Cowbirds collected on the study area contained larvae or pupae of noctuid moths (86% of the stomachs contained pupae or larvae of Mocis latipes and 14% contained larvae of Melipotis ochrodes).

Unlike Mocis latipes and Melipotis ochrodes, the caterpillars Melipotis sp., Heliothis sp., Anticarsia gemmatalis, and Thecla simaethis were seasonal and available for short periods.

The differences in the species compostion of caterpillars in the stomachs of grackles and cowbirds collected on the study area was probably due to caterpillar availability and to bill morphology differences between grackles and cowbirds.

Mocis latipes forages on the blades of various species of grasses, primarily Cenchrus ciliaris, Panicum maximum, Bothriochloa pertusa, Chloris inflata, Sporobolus pyramidatus, Cynodon dactylon, and Dichanthium annulatum.

As with other species of caterpillars, outbreaks of Mocis latipes and Melipotis ochrodes were associated with periods of rainfall. After sufficient amounts of cumulative rainfall, mesquite and grasses

sprouted new vegetation, adult moths laid eggs on the new vegetation, and within ca. 8-10 days icterids located the caterpillars. Icterids foraged on caterpillars as long as caterpillars were available. Larger (e.g. > 76.2 mm) amounts of rain were often sufficient to provide ample vegetation for more than one generation of moths.

Repeated foraging on caterpillars associated with mesquite woodland by Shiny Cowbirds, Yellow-shouldered Blackbirds, and Greater Antillean Grackles suggest that these birds have apparently adapted to these periodic infestations of Nocutid larvae and realize some benefits from associating together. Although protection from predators is possibly a major benefit of mixed-species flocks of foraging icterids in southwestern Puerto Rico, the birds may gain other advantages from such associations. Such benefits possibly include: increased foraging efficiency, social or observational learning of caterpillar outbreaks, and flock cohesion through social bonding.

Shiny Cowbirds also foraged on the fruit of certain shrubs and grasses after sufficient rainfall (ca. 76.2 mm). Fruits of Cordia globosa var. humilis and Turnefortia volubilis were the most frequently observed taken by Shiny Cowbirds. The berries of Cordia globosa var. humilis appeared to be a preferred food when available. The grass seeds most frequently observed taken by Shiny Cowbirds were those of Brachiaria subquadriparia and Panicum maximum.

When drought conditions existed, Shiny Cowbirds were often found in residential or agricultural areas (e.g., at chicken pens adjacent to the Cabo Rojo National Wildlife Refuge, or the Boqueron Dairy), where they foraged on such food sources as waste corn or other grain.

grain. Additionally, cowbirds were located at this time in mesquite woodland where they often foraged on the flowers and foliage of mesquite. Shiny Cowbirds foraged on such food items until caterpillars, berries, and grass seeds again became available subsequent to sufficient cumulative rainfall, and the cycle would start anew.

On average, Shiny Cowbirds spent approximately 68% of the time foraging, 31% of the time resting and preening, and about 1% of the time drinking and/or bathing. These results are comparable with studies involving other passerines.

Nine incidences of an invitation to preen were observed between Shiny Cowbirds and Yellow-shouldered Blackbirds. Allopreening between cowbirds and blackbirds may be important in establishing and maintaining flock order or in reducing aggression between flock members when feeding.

Twenty-five separate incidences of sunbathing using the "lateral sunning position" was observed by Shiny Cowbirds. This behavior in Shiny Cowbirds in southwestern Puerto Rico probably assists with feather maintenance associated with molt.

Patalgial markers assisted me in monitoring the habitat use and movements of Shiny Cowbirds in southwestern Puerto Rico. Because of their high visibility, patalgially marked cowbirds were often easy to follow and observe, and the markers did not appear to adversely affect the behavior or flight of cowbirds. Tag retention data indicates that the technique can be useful for long-term studies.

Movements and habitat use of Shiny Cowbirds in southwestern Puerto

Rico are apparently dictated by food availability and food availability is apparently influenced by rainfall. Cowbirds are opportunistic feeders and forage on what is available.

MANAGEMENT RECOMMENDATIONS

Shiny Cowbirds

Movements and habitat use of Shiny Cowbirds in southwestern Puerto Rico appears to be dictated by food availability and food availability is apparently dependent upon rainfall. Cowbirds are opportunistic feeders and will forage on what is available. Although my results indicate that the seasonal variation in cowbird movements prohibits the identification of permanent locations that would permit improved trapping success of cowbirds, the following recommendations should be useful in the cowbird removal program:

1) Trapping efforts should be increased during periods of drought when caterpillars are not available and when cowbirds are foraging on such foods as corn, or other waste grains, and the leaves and inflorescences of mesquite.

2) At the end of the breeding season of most cowbird hosts (i.e., approximately after 1 August), large concentrations of cowbirds often occur that include numerous immatures. In most years these concentrations will probably occur during a dry period when cowbirds are concentrated at such areas as dairies, poultry pens, and pig pens. Consequently, it would be advantageous to increase trapping efforts at such locations.

3) Immature birds probably learn the locations of baited traps by following adult male and female cowbirds to such areas. Consequently, I recommend that adult males should not be killed when trapped. Immature cowbirds could follow released adult males to traps and thus enhance removal efforts. Young cowbirds also probably learn the location of caterpillar outbreaks when the fall rainy season begins. It will probably be more difficult to attract cowbirds to traps once caterpillars become available. Thus, it is important to increase trapping efforts between the end of the breeding season of most cowbird hosts and the start of the fall rainy season.

4) Because cowbirds probably learn the location of traps, I recommend that established traps not be moved to locations unfamilar to cowbirds. To increase trapping efforts, I suggest that new traps be constructed and placed at locations where cowbirds are known to concentrate. I recommend the following locations: a) the Corozo chicken pens adjacent to the refuge (pens at this location are covered with wire mesh almost identical in size to trap openings on the refuge; consequently, cowbirds feeding on corn at this location are accustomed to going in and out of the pens and could be easily attracted to a baited trap adjacent to the pens), b) in mesquite woodland ca. 0.5 km west of Papayo Salinas near La Parguera, and c) in mesquite woodland directly north of the Bahia Sucia roost and west of the fishermen's cooperative (although a trap has previously been used just east of the fishermen's cooperative, it is often not in operation). Cowbirds often shift their roosts and those that forage on the refuge or at adjacent chicken pens

frequently used the Bahia Sucia roost at night. A trap placed just west of the fishermen's cooperative may be attractive to cowbirds when they are using this roost.

5) I recommend that larger traps (similar to those currently used on the Cabo Rojo National Refuge) and more live cowbird decoys be used to attract birds.

6) During periods of drought, when cowbirds are foraging on cereal grains, the locations of cowbird concentrations could be determined by talking to landowners who have chickens or livestock. Researchers working on a cowbird removal program should allocate part of their time contacting such individuals.

Yellow-shouldered Blackbird and Mesquite Woodland

My results suggest that Yellow-shouldered Blackbirds along with other icterids in southwestern Puerto Rico have adapted to the cyclic abundance of caterpillars, especially in mesquite woodland. Consequently, I recommend that mesquite woodland in southwestern Puerto Rico be protected and managed to benefit the endangered Yellow-shouldered Blackbird. Although few large, contiguous stands of mesquite woodland (Fig. 26) remain in southwestern Puerto Rico, I found that this habitat is important to the blackbird. Unfortunately, one stand I observed blackbirds use (Fig. 6) has already been destroyed. Mesquite woodland adjacent to the DNR refuge was cleared in July 1987

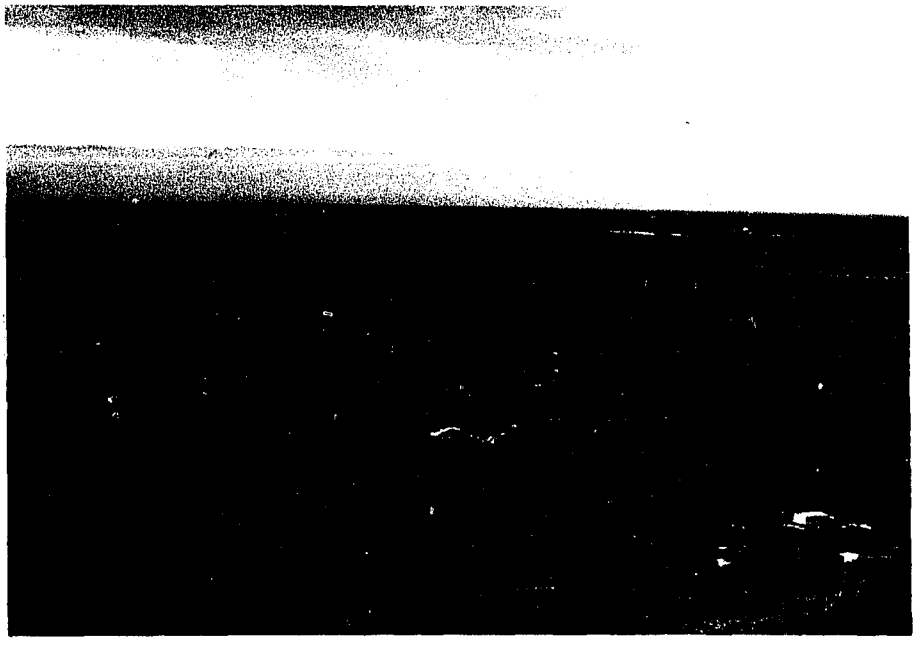


Figure 26. View of major remaining stand of mesquite woodland within Arroyo Cajul flood plain and proposed Voice of America site, southwestern Puerto Rico, 1988.

for the Monte Carlo Estates residential development (Fig. 27) without the proper permits (pers. commun., Felix Lopez, U.S. Fish and Wildlife Service, Caribbean Field Office, Boqueron, Puerto Rico, August 1987).

Although mesquite woodland is an exotic habitat, it appears to be compatible with native ucar and Yellow-shouldered Blackbirds have apparently adapted to habitat changes and the periodic outbreaks of caterpillars associated with this ecosystem. Additionally, this habitat is apparently ecologically similar to the original grassland savannah of southwestern Puerto Rico. Icterids elsewhere have been shown to adapt to alterations of their native habitats. For example, because of the elimination of winter flooding, the drainage of marshes, and the cultivation of native prairies and alkali flats, Neff (1937) feared that the Tri-colored Blackbird (Agelaius tricolor) in California would be unable to adapt to these changes in its native habitat and would thus be in danger of extinction. Orians (1961), however, indicated that the Tri-colored Blackbird adjusted well to the conversion of its native habitats to croplands and added that it was "one of the passerines best adapted to utilize the abundant supply of insects in agricultural lands of the valleys of California during the breeding season." In Puerto Rico, the Yellow-shouldered Blackbird has not only benefited from mesquite woodland, but its survival may be partly dependent on the protection and proper management of this habitat.

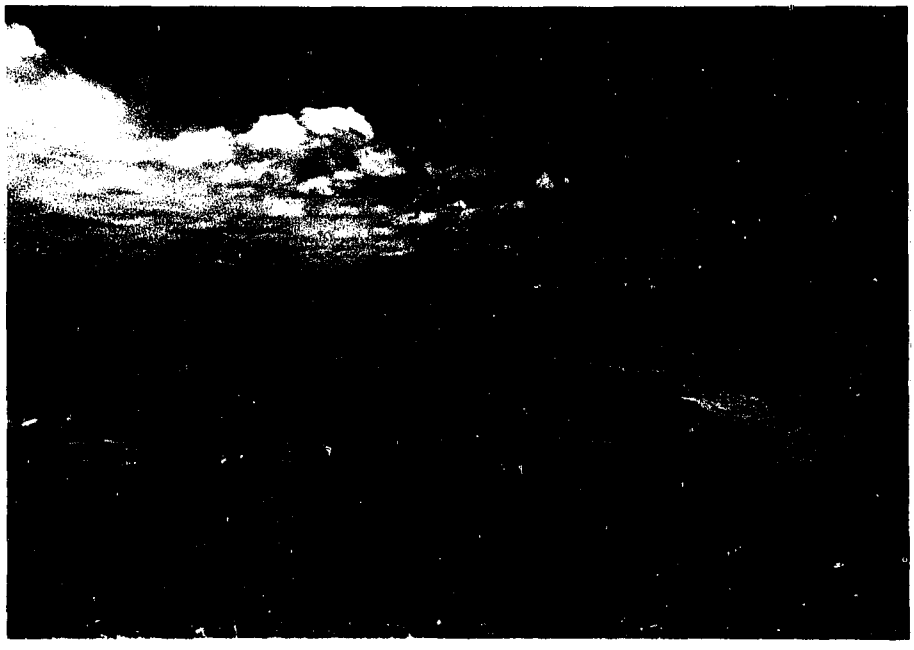


Figure 27. Destruction of mesquite woodland for Monte Carlo Estates, adjacent to Puerto Rican Department of Natural Resources' Refugio de Aves, 15 July 1987.

I recommend that mesquite woodland in southwestern Puerto Rico be managed in the following manner:

1) My research indicates that Yellow-shouldered Blackbirds and other icterids in southwestern Puerto Rico apparently benefit from an open understory and an open to semi-open overstory. Consequently, I recommend that cattle grazing be allowed and encouraged in tracts of mesquite woodland. Grazing enables mesquite woodland to remain in early successional stages by promoting grass reproduction and by preventing the establishment of unwanted shrubs. I noted that the availabiltiy of caterpillars to foraging icterids is often dictated by the grazing intensities within mesquite woodlands. In areas where grazing is heavy, caterpillars are available to icterids for shorter periods than areas where grazing is less intense. Thus, I recommend that, where possible, low intensity grazing intensity be promoted.

2) Mesquite is an important source of charcoal and fence posts in southwestern Puerto Rico. Farmers often remove branches of suitable size from mesquite for posts and charcoal. Smaller branches are then trimmed and this debris is left on the ground. Trimming mesquite allows sunlight to reach the ground, thus promoting the growth of a grass understory. Because of the spines on the branches of mesquite, cattle are reluctant to graze on grasses protruding from such debris on the ground. The additional grass vegetation provides food for Mocis latipes. Icterids often use mesquite debris as perches to reach caterpillars on grass emerging from the brush piles (Fig. 28). I

Figure 28. Brush piles often used for perches by foraging icterids when feeding on caterpillars, southwestern Puerto Rico, 1987-1988.

recommend that this practice be promoted.

3) Mesquite should be regularly thinned. Studies in the southwestern United States indicate that if mesquite is not controlled by regular thinning, the species may take over areas and form dense thickets (e.g., Fisher et al. 1959). I recommend that mesquite woodland be maintained in a semi-open state with a predominantly grass understory. Such conditions approximate the native, grass savannahs that formerly occurred on the southern end of the island.

4) Although drinking and bathing constituted only about 1% of the daily activity budget of Shiny Cowbirds, available fresh water is obviously important to cowbirds and other icterids in southwestern Puerto Rico. I did not record separate activity budgets for Yellow-shouldered Blackbirds, but blackbirds were often observed bathing and drinking with Shiny Cowbirds and Greater Antillean Grackles. I recommend that permanent sources of water be provided in mesquite woodland. Icterids apparently prefer drinking and bathing areas that a) enable birds to spot potential predators, b) are devoid of thick vegetation, c) provide water that is not too deep (i.e., water that is no deeper than the length of their legs, ca. 5 cm) (pers. obs.). Ponds or watering holes with gradually sloping banks seem to be preferred by icterids over those with steep banks (pers. obs.). It is possible that brush placed in ponds could be used by icterids for watering and bathing perches.

5) Mesquite woodland on the Cabo Rojo National Wildlife Refuge provides excellent potential habitat for the endangered Yellow-shouldered Blackbird. Although the proper grass hosts (i.e., Cenchrus ciliaris, Bothriochloa pertusa, and Panicum maximum) exist in the understory of mesquite woodland, it is entirely too thick to be attractive to the blackbird. Additionally, because culms of Cenchrus ciliaris are too old and woody, they provide little vegetation for Mocis latipes. Controlled burning would be effective in maintaining the grass at the correct density but would be harmful to the mesquite. In August 1988, a fire on the southern border of the refuge killed many of the mesquite (Fig. 29), and thus, controlled burning would probably be an inappropriate management tool. On one study site in Texas, mesquite (Prosopis velutina) had not reinvaded areas burned 15 years earlier (Humphrey 1949). I recommend that the ground vegetation within mesquite woodland on the refuge be periodically mowed and disked, or that livestock be allowed to graze in these areas.

6) Caterpillars associated with mesquite woodland apparently respond to cyclic periods of rainfall. During periods of drought adult moths possibly migrate from the arid southwestern coast, inland to areas of more abundant rainfall where vegetation is sufficient for moths to rear additional generations. When the dry southwestern coast again receives sufficient rainfall, vegetation responds to the moisture and sprouts new growth. I believe that adult moths then return to these areas, lay their eggs on the new vegetation and a new generation of caterpillars is initiated.

Figure 29. Mesquite killed by fire, Cabo Rojo National Wildlife Refuge, August 1988.

After a rain of 279.4 mm in late August, I observed large numbers of caterpillars and numerous adult moths. Two peaks in rainfall occur in southwestern Puerto Rico (Fig. 30, Cook & Gleason 1928; Garcia-Molinari 1952). The first, which usually occurs in May (Fig. 30), coincides with the breeding season of the Yellow-shouldered Blackbird. In some years, however, no peak is received in May, or it is delayed until June (e.g., 1987). Consequently, if there is insufficient rainfall, caterpillars associated with mesquite woodland (especially those species that feed on grasses) may be unavailable to nesting blackbirds. Although blackbirds may find alternate prey for nestlings during such conditions, the availability of an abundance of such species as Mocis latipes and Melipotis ochrodes could insure nest success and juvenile survival. By irrigating mesquite woodland during periods of drought, it may be possible to attract adult moths of Mocis latipes and Melipotis ochrodes to mesquite woodland, where they can rear successive generations of caterpillars. If this is done during the breeding season of the blackbird and if the blackbird can locate the caterpillars, an abundant food source would be available to blackbird nestlings. I recommend that such an experiment be attempted on the Cabo Rojo National Wildlife Refuge. If the experiment is successful, other mesquite woodlands could be managed in a similar manner.

Mesquite woodland on the refuge should be irrigated sometime between April and June, when drought conditons exist. This is an important consideration. If mesquite woodland is irrigated during a wet period, caterpillar outbreaks would be widespread and it would

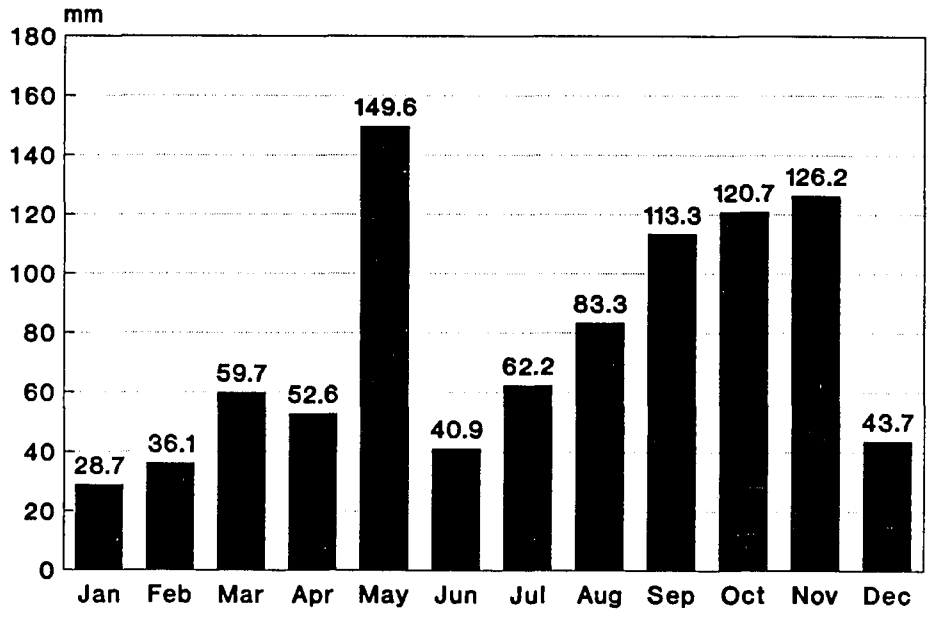


Figure 30. Average monthly rainfall, Cabo Rojo National Wildlife Refuge, 1981-1989, showing May and fall peaks, southwestern Puerto Rico.

therefore be difficult to attract blackbirds solely to the refuge. Under such conditions, blackbirds would probably forage on caterpillars closer to traditional breeding areas and roost sites. Water for irrigation on the refuge could be obtained from an existing well near the western border of the refuge. Adult moths of Mocis latipes and Melipotis ochrodes may return to breed in areas where they foraged as larvae. If so, it may be possible to increase the chances that adult moths return to the refuge when grasses are irrigated by obtaining numerous larvae from other areas during wet periods (when caterpillars are abundant) and transplanting them onto grasses on the refuge.

7) If attempts to attract adult moths of Mocis latipes and Melipotis ochrodes to irrigated mesquite woodland on the refuge are successful, then Yellow-shouldered Blackbirds may be attracted to the new food source. If the blackbirds can be attracted to the refuge during their breeding season, it may be possible to induce the blackbirds to nest on the refuge. This can be attempted by placing artificial nest sites in mesquite and ucars adjacent to areas that have caterpillars.

8) The thick stands of Cenchrus ciliaris, Bothriochloa pertusa, Panicum maximum, and other understory vegetation on the refuge apparently provide ideal habitat for the small Indian mongoose. The high density of this mammalian predator may be potentially harmful to foraging and nesting Yellow-shouldered Blackbirds (Post and Wiley 1976). Consequently, I recommend that a trapping program be initiated to reduce the high density of mongooses on the refuge. Additionally, I recommend

that at least a 20-30 meter buffer zone be established between unmanaged sections of mesquite woodland and irrigated areas. This zone would assist icterids foraging on the ground to spot a mongoose. The zones could be maintained by frequent mowing.

9) It is probably impossible to attract the Yellow-shouldered Blackbird to irrigated areas of mesquite on the Cabo Rojo National Wildlife Refuge without also attracting Greater Antillean Grackles and Shiny Cowbirds. If so, trapping of cowbirds should be considered during such periods. Additionally, Yellow-shouldered Blackbirds trapped at the same time could be banded and released.

10) Cook and Gleason (1928) stated that ucar was the climax species in many areas of southwestern Puerto Rico. Because it is used by blackbirds for nesting in upland areas (Post 1981; probably more frequently formerly than currently reported), ucar is an important component of mesquite woodland. I could find no data indicating that the exotic mesquite is a harmful competitor to the native ucar. Although I believe that the two species are possibly compatible, additional research is needed to evaluate potential competitive interactions. Recently, a planting program of ucar was initiated on the Cabo Rojo National Wildlife Refuge. I recommend that this program be continued and expanded and that ucar be protected.

Coastal Scrub

Much of the acreage between areas adjacent to the Pitahaya Roost and La Parguera is dominated by thick, coastal scrub. According to Cook and Gleason (1928), this area was formerly an ucar climax forest that reverted to the present habitat when the area was cleared for agriculture and pasture. During my study, I rarely observed icterids in this habitat. Blackbirds could probably benefit from such areas if these areas were bulldozed, and replaced with an ucar/mesquite woodland with a predominantly grass understory. I recommend that Section 7 consultations be initiated to determine if such management recommendations pose a threat to the endangered blackbird. Because coastal scrub provides poor forage for cattle, managing such areas for the blackbird would benefit local ranchers as well.

Threat of Pesticides to the Yellow-shouldered Blackbird

No data exist to determine whether the pesticides currently used on cultivated crops in southwestern Puerto Rico are harmful to the endangered blackbird. Blackbirds that forage on caterpillars contaminated with organophosphates or carbamates could potentially suffer ill side effects, especially from the inhibition of brain cholinesterase levels. I recommend that research be initiated to determine if cholinesterase levels in blackbirds are being depressed due to pesticide posioning. Because of their abundance and frequent association with blackbirds, cowbirds and grackles would make excellent surrogates for such a study.

Proposed Voice of America Site

In 1986-87, the United States federal government (Army Corps of Engineers, Jacksonville, Florida) proposed that land northwest of the Pitahaya Roost be considered as a possible site for the construction of a Voice of America radio relay station. Most of the proposed site overlaps mesquite woodland that I found to be important to icterids in southwestern Puerto Rico. In 1986, Mantek Services Inc.-South Carolina, 1007 Bankton Drive, Hanahan, South Carolina 29406, was contracted to assess the importance of the land under consideration to the endangered Yellow-shouldered Blackbird. Because Mantek's study was conducted from January through August, prior to the fall rainy season, the company's staff was unable to observed icterids foraging on caterpillars associated with the grass understory of mesquite woodland following sufficient rain. Consequently, Mantek (unpub. report) concluded that upland areas (including mesquite woodland) were not important to the blackbird and further recommended that: 1) grazing be terminated and 2) watering areas be eliminated. Such recommendations are not compatible with the results of my study. I believe that mesquite woodland northwest of the Pitahaya Roost is extremely important to the Yellow-shouldered Blackbird and that it should be managed to benefit the species. Because my research indicates that this area is important to the blackbird, it is my opinion that approval of the proposed Voice of America site and accompanying towers would seriously jeopardize the species.

LITERATURE CITED

Abramson, M. 1979. Vigilance as a factor influencing flock formation among Curlews, Numenius arquata. Ibis 121:213-216.

Alberts, H.W., and O. Garcia-Molinari. 1943. Pastures of Puerto Rico and their relation to soil conservation U.S.D.A. Misc. Publ. 513.

Alcock, J. 1969a. Observational learning in birds. Ibis 111:308-321.

Alcock, J. 1969b. Observational learning by Fork-tailed Flycatchers (Muscivora tyrannus). Anim. Behav. 17:652-657.

Alcock, J. 1973. Cues used in searching for food by red-winged blackbirds (Agelaius phoeniceus). Behavior 46:176-188.

Allee, W.C. 1938. The social life of animals. Norton & Co. 293pp.

American Ornithologists' Union. 1983. Checklist of North American birds. 6th. ed. American Ornithologists' Union, Washington, D.C. 877 pp.

American Ornithologists' Union. 1989. Orinthol. Newsletter No. 73:1-12.

Andersson, M., F. Gotmark and C.G. Wilklund. 1981. Food information in the black-headed gull, Larus ridibundus. Behav. Ecol. Sociobiol. 9:199-202.

Arendt, W.J. and T.A. Vargas-Mora. 1984. Range expansion of the Shiny Cowbird in the Dominican Republic. J. Field Ornith. 55:104-107.

Austin, G.T., and E.L. Smith. 1972. Winter foraging ecology of mixed insectivorous bird flocks in oak woodland in southern Arizona. Condor 74:17-24.

Bazely, D.R. 1987. Snow buntings feeding on leaves of salt-marsh grass during spring migration. Condor 89:190-192.

Bayer, R. 1982. How important are bird colonies as information centers? Auk 99:31-40.

Beard, J.S. 1944. Climax vegetation in tropical America. Ecology 25(2):127-158.

Beard, J.S. 1955. The classification of tropical American vegetation-types. Ecology 36(1):89-100.

Biaggi, V., Jr. 1963. Record of the White Pelican and additional information on the Glossy Cowbird from Puerto Rico. Auk 80:198.

Bond, J. 1946. The birds of Mona Island. Notulae Naturae 176:1-10.

Bond, J. 1956. Check-list of birds of the West Indies. 4th ed. Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1961. Sixth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1964. Ninth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1966. Eleventh supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1967. Twelfth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1971. Sixteenth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1973. Eighteenth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1976. Twentieth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1977. Twenty-first supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bond, J. 1984. Twenty-fifth supplement to the Check-list of birds of the West Indies (1956). Academy Natural Sciences, Philadelphia, Pa.

Bray, O.E., K.H. Larsen, and D.F. Mott. 1975. Winter movements and activities of radio-equipped starlings. J. Wildl. Manage. 39:795-801.

Bray, O.E., W.C. Royael, Jr., J.L. Guarino, and R.E. Johnson. 1979. Activities of radio-equipped Common Grackles during fall migration. Wilson Bull. 91:78-87.

Brittingham, M.C. and S.A. Temple. 1983. Have cowbirds caused forest songbirds to decline? Bioscience 33:31-35.

Britton, N.L., and P. Wilson. 1924. Scientific survey of Porto Rico and the Virgin Islands. Vol. 4. New York Acad. of Sciences.

Broom, D.M., W.J. Dick, C.E. Johnson, D.I. Sales, and A. Zahavi. 1976. Pied Wagtail feeding and roosting behaviour. Bird Study 23:267-279.

Brooke, M. D. 1985. The effect of allopreening on tick burdens of molting Eudyptid Penguins. Auk 102:893-895.

Brown, C.R. 1986. Cliff swallow colonies as information centers. Science 234:83-85.

Brown, L.H., and D. Amadon. 1968. Eagles, hawks and falcons of the World. 2 vols. McGraw-Hill Book Co., New York. 945pp.

Buckley, P.A., and F.G. Buckley. 1970. Notes on the distribution of some Puerto Rican birds and the courtship behavior of the White-tailed Tropicbirds. Condor 72:83-86.

Burkart, A. 1976a. A monograph of the genus Prosopis (Leguminosae subfam. Mimosoideae). J. Arnold Arb. 57(3):219-249.

Burkart, A. 1976b. A monograph of the genus Prosopis (Leguminosae subfam. Mimosoideae). Catalogue of the recognized species of Prosopis. J. Arnold Arb. 57(4):450-525.

Burton, R. 1985. Bird behavior. Alfred A. Knoppf, New York. 224pp.

Caccamise, D.F., and J. Fischl. 1985. Patterns of association of secondary species in roosts of Euopean Starlings and Common Grackles. Wilson Bull. 97:173-182.

Caccamise, D.F., and D.W. Morrison. 1986. Avian communal roosting: implications of diurnal activity centers. Amer. Nat. 128:191-198.

Caldwell, G.S. 1981. Attraction to tropical mixed-species heron flocks: proximate mechanisms and consequences. Behav. Ecol. Sociobiol. 8:99-103.

Cavalcanti, R.B. and T.M. Pimentel. 1988. Shiny Cowbird parasitism in central Brazil. Condor 90:40-43.

Chapman, F.M. 1928. The nesting habits of Wagler's Oropendola (Zarhynchus wagleri) on Barro Colorado Island. Bull. Amer. Mus. Nat. Hist. 58:123-166.

Cody, M.L. 1971. Finch flocks in the Mojave Desert. Ther. Pop. Biol. 2:142-158.

Colon, E. D. 1930. Datos sobre la agricultura de Puerto Rico antes de 1898. San Juan, Puerto Rico.

Cook, M.T. and H.A. Gleason. 1928. Ecological survey of the flora of Puerto Rico. J. Dept. Agri. P.R. 12(1,2):3-139.

Crook, J.H. 1965. The adaptive significance of avian social organizations. Symp. Zool. Soc. Lond. 14:181-218.

Croze, H. 1970. Searching image in Carrion Crows. Hunting strategy in a predator and some anti-predator devices in camouflaged prey. Z. Tierpsychol. Beh. 5:1-86.

Cruz, A. and J.W. Wiley. 1989. The decline of an adaptation in the absence of a presumed selection pressure. Evolution 43(1):55-62.

Cruz, A., T. Manolis, and J.W. Wiley. 1985. The Shiny Cowbird: a brood parasite expanding its range in th Caribbean Region. Pp. 607-620 in Neotropical Ornithology, P.A. Buckley, M.S. Foster, E.S. Morton, R.S. Ridgely, and F.G. Buckley (eds.). Ornith. Mon. No. 36. 1041 pp., A.O.U., Washington, D.C.

Cullen, J.M., and N.P. Ashmole. 1963. The Black Noddy... on Ascension Island. Part 2. Behavior. Ibis 1036:423-446.

Cummings, J.L. 1985. Movements of adult male Red-winged Blackbirds color-tagged in Colorado. North Am. Bird Bander 10(3):73-75.

Cummings, J.L. 1987. Nylon fasteners for attaching leg and wing tags to blackbirds. J. Field Ornith. 58(3):265-269.

Custer, T.W. and R.G. Osborn. 1978. Feeding habitat use by colonially-breeding herons, egrets, and ibises in North Carolina. Auk 95:733-743.

Danforth, S.T. 1931. Puerto Rican ornithological records. J. Dept. Agric. Univ. Puerto Rico 19:439-472.

Danforth, S.T. 1932. The dwarf cowbird (Molothrus bonariensis minimus) in St. Lucia. Auk 49:96-97.

Danforth, S.T. 1936. Los parajaros de Puerto Rico. Rand, McNally & Co., New York.

Dean T.W. 1985. Behavioral biology of the striped grass looper, Mocis latipes (Guenee), in north-central Florida. Ph.D. Dissertation, Univ. Florida, Gainesville. 122pp.

De Groot, P. 1980. Information transfer in a socially roosting weaverbird (Quelea quelea: Ploceinae): an experimental study. Anim. Behav. 28:1249-1254.

Des Granges, J.L. 1978. Adaptive value of social behaviour in the Great Blue Heron (Ardea herodias). Proc. Colonial Waterbird Group 1978:192-201.

Diamond, A.W. 1973. Habitats and feeding stations of St. Lucia forest birds. Ibis 115:313-329.

Dolbier, R.A., P.P. Woronicki, A.R. Stickley, Jr., and S.B. White. 1978. Agricultural impact of a winter population of blackbirds and starlings. Wilson Bull. 90:31-44.

Dow, D.D. 1968. Allopreening invitation dispaly of a Brown-headed Cowbird to Cardinals under natural conditions. Wilson Bull. 80:494-495.

Duecker, G. 1976. Learning of three different positions in birds. Z. Tierspychol. 42:301-314.

Dunham, D.W. 1966. Maintenance activities of the Rose-breasted Grosbeak. Wilson Bull. 78(1):68-78.

Erwin, R.M. 1977. Foraging and breeding adaptations to different food regimes in three seabirds: the Common Tern (Sterna hirundo), Royal Tern (Sterna maxima), and Black Skimmer (Rhychops niger). Ecology 58:389-397.

Erwin, R.M. 1978. Coloniality om terns: the role of social feeding. Condor 80:211-215.

Evans, R.M. 1982a. Foraging-flock recruitment at a Black-billed Gull colony: implications for the information center hypothesis. Auk 99: 24-30.

Evans, R.M. 1982b. Flock size and formation in Black-billed Gulls. Can. J. Zool. 60:1806-1811.

Evans, R.M. 1983. Do secondary roosts function as information centers in black-billed gulls? Wilson Bull. 95(3):461-462.

Ewel, J.J., and J.L. Whitmore. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. U.S.D.A. Forest Service Res. Paper ITF-18, 73pp.

Fischer, D.H. 1981. Winter time budgets of Brown Thrashes. J. Field Ornith. 52(4):304-308.

Fisher, C.E. 1977. Mesquite and modern man in southwestern North America. Pp. 177-199 in Mesquite. Its biology in two desert scrub ecosystems, B.B. Simpson (ed.) US/IBP Synthesis Series I 4, Dowden, Hutchinson & Ross, Inc. Stroudsburg, Pa., 250 pp.

Fisher, C.E., C.H. Meadors, R. Behrens, E.D. Robison, P.T. Marion, and H.L. Martin. 1959. Control of mesquite on grazing land. Texas Agric. Exp. Stn. Bull. 935:1-23.

Fitzpatrick, J.W. 1975. A record of allopreening in the Barred Owl. Auk 92:598-599.

Fleming, T.H. 1981. Winter roosting and feeding behavior fo pied wagtails Motacilla alba near Oxford, England. Ibis 123:463-476.

Forsman, E.D., and H.M. Wight. 1979. Allopreening in owls: what are its functions? Auk 96:525-531.

Fraga, R.M. 1978. The Rufous-collared Sparrow as host of the Shiny Cowbird. Wilson Bull. 90:271-284.

Friedmann, H. 1929. The cowbirds. A study in the biology of social parasitism. C.C. Thomas, Springfield, Illinois.

Friedmann, H. 1963. Host relations of the parasitic cowbirds. U.S. Natl. Mus. Bull. No. 233.

Friedmann, H. 1971. Further information of the host relations of the parasitic cowbirds. Auk 88:239-255.

Friedmann, H., and L. Kiff. 1985. Parasitic cowbirds and their hosts. Proc. West. Found. Vert. Zool. No. 235:1-75.

Friedmann, H., L. Kiff, and S.I. Rothstein. 1977. A further contribution to knowledge of the host relations of the parasitic cowbirds. Smithson. Contrib. Zool. 235:1-75

Garcia-Molinari, O. 1952. Grasslands and grasses of Puerto Rico. Univ. P.R. Agri. Exp. Sta. Bull. 102. 167pp.

Gaston, H.J. 1977. Social behavior within groups of Jungle Babblers (Turdoides striatus). Anim. Behav. 25:828-848.

Gaston, T. 1987. Seabird citadels of the Arctic. Nat. Hist. 96:54-59.

Gibb, J. 1947. Sunbathing by birds. Brit. Birds 40:172-174.

Gleason, H.A. and M.T. Cook. 1927. Scientific survey of Porto Rico and the Virgin Islands: plant ecology of Porto Rico. Vol. 7, Parts 1 and 2. New York Acad. of Sciences. pp. 1-173.

Goodwin, D. 1983. Pigeons and doves of the world, 3rd ed. Brit. Mus. of Nat. Hist., London. 363pp.

Gori, D.F. 1988. Colony-facilitated foraging in yellow-headed blackbirds: experimental evidence for information transfer. Ornis Scandinavica 19:224-230.

Grayce, R.L. 1957. Range extensions in Puerto Rico. Auk 74:106.

Greene, E. 1987. Individuals in an osprey colony discriminated between high and low quality information. Nature 329:239-241.

Greig-Smith, P.W. 1978. Imitative foraging in mixed species flocks of Seychelles birds. Ibis 120:233-235.

Grubb, T.C., Jr. 1987. Changes in the flocking behaviour of wintering English titmice with time, weather, and supplementary food. Anim. Behav. 35:794-806.

Haas. R.H., R.E. Meyer, C.J. Scifres, and J.H. Brock. 1973. Growth and development of mesquite. Texas Agric. Exp. Stn. Res. Monogr. 1:10-19.

Hamilton, W.D. 1971. Geometry for the selfish herd. J. Theor. Biol. 31:295-311.

Harrison, C.J.O. 1946. Sun-bathing by birds. Brit. Birds 39:276.

Harrison, C.J.O. 1963. Interspecific preening display by the Rice Grackle, Psomocolax oryzivorus Auk 80:373-374.

Harrison, C.J.O. 1965. Allopreening as agonistic behavior. Behaviour 24:161-208.

Harrison, C.J.O. 1969. Further records of allopreening. Avicult. Mag. 75:97-99.

Hauser, D.C. 1957. Some observations on sunbathing in birds. Wilson Bull. 69:78-90.

Hauser, D. 1973. Comparison of anting records from two localities in North Carolina. Chat 37(4):91-102.

Hebblethwaite, M.L., and W.M. Shields. 1990. Social influences on barn swallow foraging in the Adirondacks: a test of competing hypotheses. Anim. Behav. 39:97-104.

Herrera, C.M. 1979. Ecological aspects of heterospecific flock formation in a Mediterranean passerine bird community. Oikos 33:85-96.

Hicks, L.E. 1934. A summary of cowbird host species in Ohio. Auk 51: 385-386.

Hinde, R.A. 1961. Behaviour. Pp 373-411 in A.J. Marshal (Ed.), 'Biology and comparative physiology of birds.' London. 468 pp.

Hoffman, W., D. Heinemann, and J.A. Wiens. 1981. The ecology of seabird feeding flocks in Alaska. Auk 98:437-456.

Horn, H.S. 1968. The adaptive significance of colonial nesting in the brewers blackbird blackbird (Euphagus cyanocephalus) Ecology 49(4):682-694.

Hosaka, M.J., and R.M. Ripperton. 1944. Legumes of pasture and rangeland. Univ. Hawaii Agric. Exp. Stn. Bull. 953:19-49.

Houston, D.C. 1976. Breeding of the white-backed and Ruppell's griffon vultures, Gyps africanus and G. rueppellii. Ibis 118:13-40.

Humphrey, R.R. 1949. Fire as a control of undersirable shrubs. J. Range Manage. 2:175-182.

Hunt, G.L., Jr., and M.W. Hunt. 1976. Exploitation of fluctuating food resources by Western Gulls. Auk 93:301-307.

Imhof, T.A. 1989. The spring season: March 1-May 31, 1989. Central Southern Region. Am. Birds 43(3):491-495.

Jones, T.H. 1913. Some notes on Laphgyma frugiperda S. and A. in Porto Rico. J. of Econ. Entomol. 6:230-236.

Jones, T.H., and G.N. Wolcott. 1922. The caterpillars which eat the leaves of sugarcane in Porto Rico. J. Dept. Agri. P.R. 6(1):38-50.

Kennedy R.J. 1969. Sunbathing behaviour of birds. British birds 62(7):249-258.

Kenward, R.E. 1978. Hawks and doves:factors affecting success and selection in Goshawk attacks on Wood Pigeons. J. Anim. Ecol. 47:449-460.

Kiis, A., and A.P. Moller. 1986. A field test of food information transfer in communally roosting Greenfinches. Anim. Behav. 34:1251-1255.

King, J.R. 1973. Reproductive relationships of the rufous-collared sparrow and shiny cowbird. Auk 90:19-34.

Kochert, M.N., K. Steenhof, and M.Q. Moritsch. 1983. Evaluation of patalgial markers for raptors and ravens.

Krebs, J.R. 1974. Colonial nesting and social feeding as strategies for exploiting food resources in the Great Blue Heron (Ardea herodias). Behaviour 51:99-134.

Krebs, J.R. 1978. Colonial nesting in birds with special reference to the Ciconiiformes. Pp. 299-314 in Wading Birds, A. Sprunt, J. Ogden, and S. Winekler (eds.). Nat. Aud. Soc. Res. Rep. No. 7. National Audubon Society, New York.

Krebs, J.R., M.H. MacRoberts and J.M. Cullen. 1972. Flocking and feeding in the great tit Parus major - an experimental study. Ibis 114:507-530

Kushlan, J.A. 1977. The significance of plumage colour in the formation of feeding aggregations of ciconiiformes. Ibis 119:361-363.

Langridge, H.P. 1989. The spring season: March 1-May 31, 1989. Florida Region. Am. Birds 43(3):467-470.

Lanyon, W.E. 1958. The motivation of sunbathing in birds. Wilson Bull. 70(3):280.

Lazarus, J. 1972. Natural selection and the functions of flocking in birds: a reply to Murton. Ibis 114:556-558.

Liogier, H.A., and L.F. Martorell. 1982. Flora of Puerto Rico and adjacent islands: a systematic synopsis. Editorial de la Universidad de Puerto Rico, Rio Piedras. 342pp.

Little, E.L., Jr., and F.H. Wadsworth. 1964. Common trees of Puerto Rico and the Virgin Islands. U.S.D.A. Forest Service Agric. Handbook No. 249, Washington, D.C. 548pp.

Little, E.L., Jr., and F.H. Wadsworth. 1989. Revision and second printing of: Common trees of Puerto Rico and the Virgin Islands (1964). U.S.D.A. Forest Service Agric. Handbook No. 249, Washington, D.C. 556pp.

Loman, J., and S. Tamm. 1980. Do roosts serve as an "information center" for crows and ravens. Am. Nat. 115:285-289.

Lundberg, P. 1985. Time-budgeting by Starlings, Sturnus vulgaris: time minimizing, energy maximizing, and the annual cycle organization. Oecologia (Berlin) 67:331-337.

Mac Donald, M.A. 1977. Adult mortality and fidelity to mate and nest site in a group of marked Fulmars. Bird Study 24:165-168.

Maldonado-Capriles, J., and Colon-Ferrer, M.A. 1973. Severe attack on sugarcane and grasses by Mocis latipes (Guenee), (Lepidoptera: Noctuidae) in southwest Puerto Rico. J. of Agri. Univ. P.R. 57(4):248-249.

Martin, S.C. 1948. Mesquite seeds remain viable after 44 years. Ecology 29:393.

Martorell, L.F. 1975. Annotated food plant catalog of the insects of Puerto Rico. Univ. P.R. Agric. Exp. Stn, Dep. of Ent. 303pp.

Mason, P. 1986a. Brood parasitism in a host generalist, the Shiny Cowbird:I. The quality of different species as hosts. Auk 103:52-60.

Mason, P. 1986b. Brood parasitism in a host generalist, the Shiny Cowbird:II. Host selection. Auk 103:61-69.

Mason, J.R. and R.F. Reidinger. 1981. Effects of social facilitation and observational learning on feeding behavior of the red-winged blackbird. (Agelaius phoeniceus) Auk 98:778-784.

Mason, J.R. and R.F. Reidinger. 1982. Observational learning of food aversions in red-winged blackbirds. (Agelaius phoeniceus) Auk 99:548-554.

Mayfield, H.F. 1960. The Kirtland's Warbler. Cranbook Inst. Sci. Bull. No. 40.

Mayfield, H.F. 1961. Cowbird parasitism and population of the Kirtland's Warbler. Evolution 15:174-179.

Mayfield, H.F. 1965. The Brown-headed Cowbird, with old and new hosts. Living Bird 4:13-28.

Mayfield, H.F. 1972. Third decennial census of Kirtland's Warbler. Auk 89:263-268.

Mayfield, H.F. 1973. Census of Kirtland's Warbler in 1972. Auk 90:684-685.

Mayfield, H.F. 1975. The numbers of Kirtland's Warblers. Jack Pine Warbler 53(2):39-47.

Mayfield, H.F. 1977. Brown-headed cowbird: agent of extermination. Am. Birds 31(2):107-113.

Mayfield, H.F. 1978. Brood parasitism: reducing interactions between Kirtland's Warblers and Brown-headed Cowbirds. Pp. 85-91 in Endangered birds: management techniques for preserving threatened species, S.A. Temple (ed.), Proceedings of the symposium on management for preserving birds, 17-20 August, 1977, Madison, Wisconsin. Univ. Wisc. Press, Madison.

McKenzie, P.M., and R.E. Noble. 1989. Notes on a large foraging concentration of the endangered Yellow-shouldered Blackbird (Agelaius xanthomus) in southwestern Puerto Rico. Caribb. J. Sci. 25(1-2):90-91.

McKenzie, P.M., R.E. Noble, L.E. Urbatsch, and G.R. Proctor. 1989. A new locality for Digitaria eggersii (POACEAE) in the West Indies. Caribb. J. Sci. 25(1-2):88-90.

Mock, D.W., T.C. Lamey, and D.B.A. Thompspn. 1988. Falsifiability and the information centre hypothesis. Ornis Scandinavica. 19:231-248.

Mooney, H.A., B.B. Simpson, and O.T. Solbrig. 1977. Phenology, morphology, physiology. Pp. 26-43 in Mesquite. Its biology in two desert scrub ecosystems, B.B. Simpson (ed.) US/IBP Synthesis Series I 4, Dowden, Hutchinson & Ross, Inc. Stroudsburg, Pa., 250pp.

Morse, D.H. 1970. Ecological aspects of some mixed-species foraging flocks of birds. Ecol. Mon. 40(1):119-168.

Morse, D.H. 1977. Feeding behavior and predator avoidance in heterospecific groups. Bioscience 27:332-339.

Moynihan, M. 1962. Some adaptations which help to promote gregariousness. Proc. 12th. Int. Ornithol. Congr. pp. 523-541.

Mueller, H.C. 1972. Sunbathing in birds. Z. Tierpsychol. 30:253-258.

Murton, R.K. 1971a. The significance of a specific search image in the feeding behaviour of the Wood Pigeon. Behaviour 39:10-42.

Murton, R.K. 1971b. Why do some bird species feed in flocks? Ibis 113:534-536.

Myers, J.P. 1980. Territoriality and flocking by Buff-breasted Sandpipers: variations in non-breeding dispersion. Condor 82:241-250.

Neff, J. 1937. Nesting distribution of the Tri-colored Redwing. Condor 39:61-81.

Ng, D., and B.D. Jasperson. 1984. Interspecific allopreening between Crested Caracara and Black Vulture. Condor 86:214-215.

Ogden, J.C. 1989. The winter season: Dec. 1, 1988-Feb. 1989. Florida Region. Am. Birds 43(2):303-311.

Orians, G.H. 1961. The ecology of blackbird (Agelaius) social systems. Ecological Monographs 31(3):285-312.

Orians, G.H. 1985. Blackbirds of the Americas. Univ. of Wash. Press, Seattle. 163pp.

Page, G., and D.F. Whitacre. 1975. Raptor predation on wintering shorebirds. Condor 77:73-83.

Payne, R.B. 1969. Giant Cowbird solicits preening from man. Auk 86:751-752.

Post, W. 1981. Biology of the Yellow-shouldered Blackbird Agelaius on a tropical island. Bull. Fla. State Mus. Biol. Sci. 26(3):125-202.

Post, W. 1982. Why do Grey Kingbirds roost communally. Bird Behav. 4:46-49.

Post, W. and J.W. Wiley. 1976. The Yellow-shouldered Blackbird-present and future. Am. Birds 30(1):13-20.

Post, W. and J.W. Wiley. 1977a. Reproductive interactions of the Shiny Cowbird and the Yellow-shouldered Blackbird. Condor 79:176-184.

Post, W. and J.W. Wiley. 1977b. The Shiny Cowbird in the West Indies. Condor 79:119-121.

Post, W. and K.W. Post. 1987. Roosting behavior of the Yellow-shouldered Blackbird. Fla. Field Naturalist 15:93-105.

Potter, E.F. 1970. Anting in wild birds, its frequency and probable purpose. Auk 87:692-713.

Potter, E.F. and D.C. Hauser. 1974. Relationship of anting and sunbathing to molting in Wild birds. Auk 91:537-563.

Powell, G.V.N. 1985. Sociobiology and adaptive significance of interspecific foraging flocks in the Neotropics. Pp. 713-732 in Neotropical Ornithology, P.A. Buckley, M.S. Foster, E.S. Morton, R.S. Ridgely, and F.G. Buckley (eds.). Ornith. Mon. No. 36. 1041 pp., A.O.U., Washington, D.C.

Prosser, C.L., and F.A. Brown, Jr. 1961. Comparative Physiology. 2nd ed. Saunders Publ., Philadelphia. 688pp.

Pulliam, H.R. 1973. On the advantages of flocking. J. Theoret. Biol. 38:419-422.

Puttick, G.M. 1979. Foraging behavior and activity budgets of Curlew Sandpipers. Ardea 67:111-122.

Rabenold, P.P. 1983. The communal roost in eastern catharid vultures- an information center? Pp. 303-321 in Vulture biology and management, S.R. Wilbur, and J.A. Jackson (eds.). Univ. Calif. Press, Berkeley.

Rabenold, P.P. 1987a. Recruitment to food in Black Vultures: evidence for following from communal roosts. Anim. Behav. 35:1775-1785.

Rabenold, P.P. 1987b. Roost attendance and aggression in Black Vultures. Auk 104:647-653.

Rand, A.L. 1954. Social feeding behavior of birds. Fieldiana. Zoology 36:1-71.

Ricklefs, R.E. and G.W. Cox. 1972. Taxon cycles in the West Indian avifauna. Amer. Nat. 106:195-219.

Roberts, R.C. 1948. Grasslands in Puerto Rico- farming on a tropical island. Pp 629-634 in Grass, the Yearbook of Agriculture 1948. U.S.D.A. U.S. Gov. Print. Office, Washington, D.C.

Robertson, W.B., Jr. 1962. Observations on the birds of St. John, Virgin Islands. Auk 79:44-76.

Rothschild, M., and T. Clay. 1952. Fleas, flukes, & cuckoos. Collins Publ., London. 304pp.

Rothstein, S.I. 1971. A reanalysis of the inter-specific invitation to preening display as performed by the Brown-headed Cowbird (Molothrus ater). Amer. Zool. 11:638.

Rothstein, S.I. 1980. The preening invitation or head-down display of parasitic cowbirds: II. Experimental analysis for behavioural mimicry. Behavior 75:148-182.

Rothstein, S.I., J. Verner, and E. Stevens. 1980. Range expansion and diurnal changes in dispersion of the brown-headed cowbird in the Siera Nevada. Auk 97:253-267.

Royama, T. 1970. Factors governing the hunting behaviour and selection of food by the Great Tit (Parus major L.). J. Anim. Ecol. 39:619-668.

Rudebeck, G. 1950. The choice of prey and modes of hunting of predatory birds with special reference to their selective effect 1. Oikos 2:65-88.

Scott, T.W., and J.M. Grumstrup-Scott. 1983. Why do Brown-headed Cowbirds perform the head-down display. Auk 100:139-148.

Selander, R.K. 1964. Behavior of captive South American cowbirds. Auk 81:394-402.

Selander, R.K. and C.L. LaRue Jr. 1961. Interspecific preening invitation display of parasitic cowbirds. Auk 78(4):473-504.

Siegfried, W.R. 1971. Communal roosting of the Cattle Egret. Trans. Roy. Soc. S. Africa 39:419-443.

Siegel, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York. 312pp.

Simmons, K.E.L. 1967. Ecological adaptations in the life history of the Brown Booby at Ascension Island. Living Bird 6:187-212.

Simmons, K.E.L. 1986. The sunning behaviour of birds. A guide for ornithologists. Bristol Ornith. Club, Bristol, Great Britian. 119pp.

Smith, P.W., and A. Sprunt IV. 1987. The Shiny Cowbird reaches the United States. Am. Birds 41:370-371.

Sparks, J.H. 1965. On the role of allopreening invitation behavior in reducing agression among Red Avadavats, with comments on its evolution in the Spermestidae. Proc. Zool. Soc. London 145:387-403.

Stepney, P.H.R., and D.M. Power. 1973. Analysis of the eastward breeding expansion of Brewer's blackbird, plus general aspects of avian expansions. Wilson Bull. 85(4):452-464.

Stromborg, K.L., C.E. Grue, J.D. Nichols, G.R. Hepp, J.E. Hines, and H.C. Bourne. 1988. Postfledging survival of European Starlings to an organophosphorus insecticide. Ecology 69:590-601.

Swann, R.L. 1975. Communal roosting of robins in Aberdeenshire. Bird Study 22:93-98.

Taylor, E.C. 1864. Five months in the West Indies. Part II, Martinque, Dominica, and Porto Rico. Ibis 6:157-173.

Teager, C.W. 1967. Birds sunbathing. Brit. Birds 60:361-371.

Thorpe, W.H. 1956. Learning and instinct in animals. Harvard Univ. Press. Cambridge, Mass. 558pp.

Tinbergen, N. 1953. Social behavior in animals. Methuen & Co., London. 150pp.

Trusman, M. 1975. Predation and the evolution of gregariousness. I. Models for concealment and evasion. Anim. Behav. 23:779-800.

Turner, E.A. 1965. Social feeding in birds. Behaviour 24:1-46.

U.S. Fish and Wildlife Service. 1976. Determination that the Yellow-shouldered Blackbird is an endangered species and determination of critical habitat. Fed. Reg. 41:51019-510122.

U.S. Fish and Wildlife Service. 1983. Yellow-shouldered blackbird recovery plan. U.S.F.W.S., Atlanta, Ga. 23pp.

Van Dine, D.L. 1913. The insects affecting sugarcane in Porto Rico. J. Econ. Entomol. 6(2):251-257.

Verbeek, N.A. 1964. A time and energy budget study of the Brewer Blackbird. Condor 66:70-74.

Verbeek, N.A. 1972. Daily and annual time budget of the Yellow-billed Magpie. Auk 89:567-582.

Verbeek, N.A., R.W. Butler, and H. Richardson. 1981. Interspecific allopreening solicitation in female Brewer's Blackbirds. Condor 83:179-180.

Verner, J., and L.V. Ritter. 1983. Current status of Brown-headed Cowbird in the Sierra National Forest. Auk 100:355-368.

Vessem, J.V., and D. Draulans. 1987. Patterns of arrival and departure of Grey Herons, Ardea cinerea at two breeding colonies. Ibis 129:353-363.

Viksne, Jr., and M. Janaus. 1980. Breeding success of Black-headed Gull, Larus ridibundus in relation to the nesting time. Ornis. Fenn. 57:1-10.

Vine, I. 1971. Risk of visual detection and pursuit by a predator and the selective advantage of flocking behavior. J. Theor. Biol. 30:405-422.

Walkinshaw, L.H. 1983. Kirtland's Warbler: the natural history of an endangered species. Cranbook Inst. of Sci., Bloomfield Hills, Mich.

Walkinshaw, L.H., and D.A. Zimmerman. 1961. Range expansion of the Brewer Blackbird is eastern North America. Condor 63:162-177.

Waltz, E.C. 1982. Resource characteristics and the evolution of information centers. The American Naturalist 119(1):73-90.

Waltz, E.C. 1983. On tolerating followers in information centers, with comments on testing the adaptive significance of coloniality. Colonial Waterbirds 61:31-36.

Waltz, E.C. 1987. A test of the information centre hypothesis in two colonies of Common Terns, Sterna hirundo. Anim. Behav. 35:48-59.

Ward, P. 1965. Feeding ecology of the Black-faced Dioch Quela quela in Nigeria. Ibis 107:173-214.

Ward, P. and A. Zahavi. 1973. The importance of certain assemblages of birds as "information-centres" for food finding. Ibis 115:517-534.

Weatherhead, P.J. 1983. Two principal strategies in avian communal roosts. Am. Nat. 121:237-243. Wetmore, A. 1916. Birds of Porto Rico. U.S.D.A. Bull. No. 326:1-140.

Weisbrod, A.R. 1971. Grooming behaviors of the Blue Jay. Living Bird 10:271-284.

Wetmore, A. 1916. Birds of Porto Rico. U.S.D.A. Bull. 326:1-140.

Wetmore, A. 1927. The birds of Porto Rico and the Virgin Islands. New York Acad. Sci. Survey of Porto Rico and the Virgin Islands. 9:409-571.

White, S.B., R.A. Dolbier, and T.A. Bookout. 1985. Ecology, bioenergetics, and agricultural impacts of a winter-roosting population of blackbirds and starlings. Wildl. Monogr. 93. 42pp.

Wiley, J.W. 1982a. Ecology of avian brood parasitism at an early interfacing of host and parasite populations. Ph. D. Dissertation. Univ. of Miami, Coral Gables.

Wiley, J.W. 1982b. Cowbird control improves reproductive success of endangered Yellow-shoulderd Blackbird. U.S. Fish and Wildlife Service, Res. Inf. Bull. No. 82-54.

Wiley, J.W. 1985a. Bird conservation in the United States Caribbean. Pp. 107-159 in Bird Conservation 2, S.A. Temple (ed.). Univ. Wisconsin Press, Madison, Wisconsin. 181pp.

Wiley, J.W. 1985b. Shiny cowbird parasitism in two avian communities in Puerto Rico. Condor 87:165-176.

Wiley, J.W. 1988. Host selection by the Shiny Cowbird. Condor 90:289-303.

Williamson, P., and L. Grey. 1975. Foraging behavior of the Starling (*Sturnus vulgaris*) in Maryland. Condor 77:84-89.

Willis, E.O. 1972. Do birds flock in Hawaii, a land without predators? Calif. Birds 3:1-8.

Zahavi, A. 1971. The social behavior of the white wagtail *Motacilla alba alba* wintering in Israel. Ibis 113:203-211.

APPENDIX A

Patagial tag and U. S. Fish and Wildlife Service aluminum leg band numbers, and date of release for male Shiny Cowbirds, southwestern Puerto Rico, 1987

Appendix A. Male Shiny Cowbird band and patalgial marker numbers, age, and release date, southwestern Puerto Rico, 1987.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
A 1	942-50678	2nd	7 May
A 2	942-50614	Adult	7 May
A 3	942-50612	2nd	7 May
A 4	942-50701	2nd	7 May
A 5	942-50623	2nd	7 May
A 6	942-50702	2nd	7 May
A 7	942-50548	2nd	7 May
A 8	942-50662	2nd	7 May
A 9	942-50638	2nd	7 May
A 10	942-50671	2nd	7 May
A 11	942-50549	2nd	7 May
A 12	942-50657	2nd	7 May
A 13	942-50656	2nd	7 May
A 14	942-50610	2nd	7 May
A 15	942-50690	Adult	7 May
A 16	942-50670	2nd	7 May
A 17	942-50540	2nd	7 May
A 18	942-50664	2nd	7 May
A 19	862-34186	Adult	7 May
A 20	942-50524	2nd	7 May
A 21	942-50562	2nd	1 June
A 22	942-50605	1st	1 June
A 23	942-50653	2nd	14 June
A 24	942-50601	Adult	14 June
A 25	942-50742	1st	14 June
A 26	942-50744	1st	14 June
A 27	942-50752	1st	20 July
A 28	942-50741	1st	20 July
A 29	942-50753	1st	20 July
A 30	942-50755	1st	6 August
A 31	942-50943	Adult	7 August
A 32	942-50945	1st	7 August
A 33	942-50948	1st	8 August
A 34	942-50962	Adult	10 August
A 35	942-50964	1st	10 August
A 36	942-50966	1st	10 August
A 37	942-50975	1st	11 August
A 38	942-50994	2nd	12 August
A 39	-	1st	13 August
B 1	942-50704	2nd	6 May
B 2	942-50693	2nd	6 May
B 3	942-50617	2nd	6 May
B 4	942-50648	2nd	6 May

Appendix A. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
B 5	942-50708	2nd	6 May
B 6	942-50709	2nd	6 May
B 7	942-50541	2nd	6 May
B 8	942-50646	2nd	6 May
B 9	942-50676	2nd	6 May
B 10	942-50651	Adult	6 May
B 11	942-50710	2nd	6 May
B 12	942-50583	2nd	6 May
B 13	942-50631	2nd	6 May
B 14	942-50650	2nd	6 May
B 15	942-50584	2nd	6 May
B 16	942-50691	2nd	6 May
B 17	942-50673	2nd	6 May
B 18	942-50712	1st	6 May
B 19	942-50570	2nd	6 May
B 20	942-50652	2nd	6 May
B 21	942-50713	Adult	6 May
B 22	942-50593	2nd	6 May
B 23	942-50714	2nd	6 May
B 24	942-50618	2nd	6 May
B 25	942-50506	2nd	6 May
B 26	942-50532	2nd	7 May
B 27	942-50698	2nd	7 May
B 28	942-50658	Adult	7 May
B 29	942-50588	2nd	7 May
B 30	942-50539	2nd	7 May
B 31	942-50733	2nd	29 May
B 32	942-50722	1st	29 May
B 33	942-50681	2nd	29 May
B 34	942-50728	2nd	29 May
B 35	942-50725	Adult	29 May
B 36	942-50720	1st	29 May
B 37	942-50734	2nd	29 May
B 38	862-34191	Adult	29 May
B 39	942-50729	2nd	29 May
B 40	942-50732	2nd	29 May
B 41	942-50731	2nd	29 May
B 42	942-50698	2nd	14 June
B 43	942-50749	2nd	14 June
B 44	942-50750	1st	14 June
B 45	942-50730	2nd	14 June
B 46	942-50724	1st	20 July
B 47	942-50644	1st	20 July

Appendix A. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
B 48	942-50756	1st	6 August
B 49	942-50758	1st	6 August
B 50	942-50719	2nd	6 August
B 51	942-50760	1st	6 August
B 52	942-50761	2nd	6 August
B 53	942-50763	1st	6 August
B 54	942-50770	1st	6 August
B 55	942-50771	1st	6 August
B 56	942-50772	1st	6 August
B 57	942-50777	1st	6 August
B 58	942-50778	1st	6 August
B 59	942-50559	2nd	6 August
B 60	942-50780	1st	6 August
B 61	942-50781	1st	7 August
B 62	942-50782	1st	7 August
B 63	942-50787	1st	7 August
B 64	942-50790	1st	7 August
B 65	942-50791	1st	7 August
B 66	942-50793	1st	7 August
B 67	942-50794	2nd	7 August
B 68	942-50797	1st	7 August
B 69	942-50800	1st	7 August
B 70	942-50928	1st	7 August
B 71	942-50930	1st	7 August
B 72	942-50931	1st	7 August
B 73	942-50934	1st	7 August
B 74	942-50936	1st	7 August
B 75	942-50938	1st	7 August
B 76	942-50947	1st	8 August
B 77	942-50951	1st	9 August
B 78	942-50960	1st	10 August
B 79	942-50973	1st	11 August
B 80	942-50979	1st	12 August
B 81	942-50983	1st	12 August
B 82	942-50984	1st	12 August
B 83	942-50989	Adult	12 August
B 84	942-50990	Adult	12 August
B 85	942-50991	1st	12 August
B 86	942-50997	1st	12 August
B 87	-	1st	14 August
B 88	-	1st	14 August
B 89	-	1st	14 August
B 90	942-50887	2nd	16 August

Appendix A. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
B 91	942-50884	1st	16 August
B 92	942-50893	1st	16 August
B 93	942-50890	1st	16 August
B 94	942-50886	2nd	16 August
B 95	942-50889	1st	16 August
B 96	942-50872	1st	16 August
B 97	942-50891	1st	16 August
B 98	862-34180	Adult	16 August
B 99	942-50873	Adult	16 August
C 1	942-50597	2nd	6 May
C 2	942-50681	2nd	6 May
C 3	942-50519	2nd	6 May
C 4	942-50557	2nd	6 May
C 5	942-50552	2nd	6 May
C 6	942-50599	2nd	6 May
C 7	942-50615	2nd	6 May
C 8	942-50684	2nd	6 May
C 9	942-50579	2nd	6 May
C 10	942-50547	2nd	6 May
C 11	942-50594	Adult	6 May
C 12	942-50568	2nd	6 May
C 13	942-50606	2nd	6 May
C 14	942-50514	2nd	6 May
C 15	942-50585	2nd	6 May
C 16	942-50590	2nd	6 May
C 17	942-50680	2nd	6 May
C 18	942-50578	2nd	6 May
C 19	942-50643	2nd	6 May
C 20	942-50565	2nd	6 May
C 21	942-50633	2nd	6 May
C 22	942-50563	2nd	6 May
C 23	942-50721	2nd	29 May
C 24	942-50738	2nd	29 May
C 25	942-50739	2nd	29 May
C 26	942-50567	2nd	20 July
C 27	942-50645	2nd	20 July
C 28	942-50580	2nd	20 July
C 29	942-50558	2nd	20 July
C 30	942-50672	2nd	20 July
C 31	942-50882	1st	16 August

APPENDIX B

Patagial tag and U. S. Fish and Wildlife Service aluminum leg band numbers, and date of release for female Shiny Cowbirds, southwestern Puerto Rico, 1987

Appendix B. Female Shiny Cowbird band and patalgial marker numbers, age, and release date, southwestern Puerto Rico, 1987.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
A 1	942-50602	2nd	7 May
A 2	942-50636	2nd	7 May
A 3	942-50689	Adult	7 May
A 4	942-50556	2nd	7 May
A 5	942-50703	2nd	7 May
A 6	942-50513	2nd	7 May
A 7	942-50700	2nd	7 May
A 8	942-50609	2nd	7 May
A 9	942-50637	2nd	7 May
A 10	942-50507	2nd	7 May
A 11	942-50715	2nd	7 May
A 12	942-50687	2nd	7 May
A 13	942-50655	2nd	7 May
A 14	942-50622	2nd	7 May
A 15	862-34611	2nd	7 May
A 16	942-50527	2nd	7 May
A 17	942-50663	2nd	7 May
A 18	942-50523	Adult	7 May
A 19	942-50695	2nd	7 May
A 20	942-50639	2nd	7 May
A 21	942-50679	2nd	7 May
A 22	942-50696	2nd	7 May
A 23	942-50531	2nd	7 May
A 24	942-50665	2nd	7 May
A 25	942-50699	2nd	7 May
A 26	942-50555	2nd	7 May
A 27	942-50635	2nd	7 May
A 28	942-50607	2nd	7 May
A 29	942-50716	2nd	7 May
A 30	942-50740	2nd	1 June
A 31	942-50754	1st	20 July
A 32	942-50723	2nd	7 August
A 33	942-50941	1st	7 August
A 34	942-50942	1st	7 August
A 35	942-50944	1st	7 August
A 36	942-50952	1st	9 August
A 37	942-50953	1st	9 August
A 38	942-50954	1st	9 August
A 39	942-50955	1st	9 August
A 40	942-50956	1st	9 August
A 41	942-50625	2nd	10 August
A 42	942-50963	Adult	10 August
A 43	942-50965	2nd	10 August

Appendix B. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
A 44	942-50967	1st	10 August
A 45	942-50968	2nd	10 August
A 46	942-50976	1st	11 August
A 47	942-50977	Adult	11 August
A 48	-	1st	13 August
A 49	-	1st	13 August
A 50	-	2nd	14 August
A 51	-	Adult	14 August
A 52	-	1st	14 August
B 1	942-50705	2nd	6 May
B 2	942-50674	2nd	6 May
B 3	942-50707	2nd	6 May
B 4	942-50512	2nd	6 May
B 5	942-50619	2nd	6 May
B 6	942-50586	2nd	6 May
B 7	942-50598	2nd	6 May
B 8	942-50627	Adult	6 May
B 9	942-50660	2nd	6 May
B 10	942-50694	2nd	6 May
B 11	942-50543	2nd	6 May
B 12	942-50654	2nd	6 May
B 13	942-50626	2nd	6 May
B 14	942-50630	2nd	6 May
B 15	942-50711	2nd	6 May
B 16	942-50692	2nd	6 May
B 17	942-50564	2nd	6 May
B 18	942-50624	2nd	6 May
B 19	942-50667	2nd	6 May
B 20	942-50537	2nd	7 May
B 21	942-50589	2nd	29 May
B 22	942-50723	1st	29 May
B 23	942-50727	2nd	29 May
B 24	942-50736	1st	29 May
B 25	942-50735	2nd	29 May
B 26	942-50634	2nd	29 May
B 27	942-50587	2nd	29 May
B 28	942-50603	2nd	29 May
B 29	942-50632	2nd	29 May
B 30	942-50647	1st	20 July
B 31	942-50745	1st	20 July
B 32	942-50748	1st	20 July
B 33	942-50747	2nd	20 July
B 34	942-50649	1st	20 July

Appendix B. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
B 35	942-50746	1st	20 July
B 36	942-50757	1st	6 August
B 37	942-50759	1st	6 August
B 38	942-50762	1st	6 August
B 39	942-50764	1st	6 August
B 40	942-50765	2nd	6 August
B 41	942-50766	1st	6 August
B 42	942-50767	1st	6 August
B 43	942-50768	2nd	6 August
B 44	942-50769	1st	6 August
B 45	942-50773	1st	6 August
B 46	942-50774	1st	6 August
B 47	942-50775	1st	6 August
B 48	942-50776	2nd	6 August
B 49	942-50779	1st	6 August
B 50	-	1st	6 August
B 51	942-50783	1st	7 August
B 52	942-50784	1st	7 August
B 53	942-50785	1st	7 August
B 54	942-50786	1st	7 August
B 55	942-50788	1st	7 August
B 56	942-50789	1st	7 August
B 57	-	1st	7 August
B 58	942-50792	1st	7 August
B 59	942-50795	1st	7 August
B 60	942-50796	1st	7 August
B 61	942-50798	1st	7 August
B 62	942-50799	1st	7 August
B 63	942-50927	1st	7 August
B 64	942-50929	1st	7 August
B 65	942-50932	1st	7 August
B 66	942-50933	1st	7 August
B 67	942-50935	1st	7 August
B 68	942-50937	1st	7 August
B 69	942-50939	1st	7 August
B 70	942-50940	1st	7 August
B 71	942-50946	1st	7 August
B 72	942-50949	2nd	9 August
B 73	942-50950	1st	9 August
B 74	942-50957	1st	10 August
B 75	942-50958	1st	10 August
B 76	942-50959	1st	10 August
B 77	942-50961	1st	10 August

Appendix B. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
B 78	942-50969	1st	10 August
B 79	942-50970	1st	10 August
B 80	942-50971	1st	10 August
B 81	942-50972	1st	10 August
B 82	942-50974	1st	10 August
B 83	942-50978	2nd	12 August
B 84	942-50980	2nd	12 August
B 85	942-50981	1st	12 August
B 86	942-50982	1st	12 August
B 87	942-50985	2nd	12 August
B 88	942-50986	2nd	12 August
B 89	942-50987	2nd	12 August
B 90	942-50988	1st	12 August
B 91	942-50992	1st	12 August
B 92	942-50993	1st	12 August
B 93	942-50995	1st	12 August
B 94	942-50996	1st	12 August
B 95	942-50998	1st	12 August
B 96	942-50999	2nd	13 August
B 97	942-51000	1st	13 August
B 98	-	1st	14 August
B 99	942-50550	2nd	15 August
C 1	871-35718	Adult	6 May
C 2	942-50620	2nd	29 May
C 3	942-50530	2nd	6 May
C 4	942-50526	2nd	6 May
C 5	942-50595	2nd	6 May
C 6	942-50535	2nd	6 May
C 7	942-50640	2nd	6 May
C 8	942-50613	2nd	6 May
C 9	942-50616	2nd	6 May
C 10	942-50628	2nd	6 May
C 11	942-50573	2nd	6 May
C 12	942-50682	2nd	6 May
C 13	942-50642	2nd	6 May
C 14	942-50596	2nd	6 May
C 15	942-50577	2nd	6 May
C 16	942-50566	2nd	6 May
C 17	942-50551	2nd	6 May
C 18	942-50517	2nd	6 May
C 19	942-50608	2nd	6 May
C 20	942-50683	2nd	6 May
C 21	942-50561	2nd	6 May

Appendix B. Continued.

Patalgial Marker No.	USFWS Band No.	Age	Release Date
C 22	942-50510	2nd	6 May
C 23	942-50575	2nd	6 May
C 24	942-50641	Adult	6 May
C 25	942-50735	Adult	6 May
C 26	942-50660	2nd	6 May
C 27	942-50685	2nd	6 May
C 28	942-50569	2nd	6 May
C 29	942-50600	2nd	6 May
C 30	942-50560	2nd	6 May
C 31	942-50737	2nd	29 May
C 32	942-50518	2nd	30 May
C 33	-	1st	13 August
C 34	-	1st	15 August
C 35	-	1st	15 August
C 36	-	1st	16 August
C 37	942-50879	2nd	16 August
C 38	942-50878	1st	16 August
C 39	942-50885	2nd	16 August
C 40	-	1st	16 August
C 41	-	2nd	16 August
C 42	942-50875	1st	16 August
C 43	942-50892	2nd	16 August
C 44	952-17001	1st	16 August
C 45	942-50881	2nd	16 August
C 46	-	2nd	16 August
C 47	942-50880	2nd	16 August
C 48	-	1st	16 August
C 49	942-50883	1st	16 August
C 50	-	1st	16 August
C 51	942-50874	2nd	16 August
C 52	942-50889	2nd	16 August
C 53	942-50876	1st	16 August
C 54	942-50877	2nd	16 August
C 55	942-50888	2nd	16 August
C 56	-	1st	16 August
C 57	-	1st	16 August
C 58	-	1st	16 August
C 59	-	1st	16 August
C 60	942-50515	2nd	30 September
C 61	942-50751	1st	3 November

APPENDIX C

Habitat use by Shiny Cowbirds (minutes and percent of observation), southwestern Puerto Rico, 1987

Appendix C. Habitat use by Shiny Cowbirds (minutes and percent of observation), southwestern Puerto Rico, 10 May- 28 November 1987 (n= 45,744 minutes; ca. 762 hrs.).

Period	Mesquite Woodland min.	%	Residential or Agricul. min.	%	Open Field min.	%	Littoral Woodland, Mangrove, Or Scrub min.	%
31 May-6 June	827	45	0	0	0	0	1,001	55
7-13 June	2,705	98	0	0	0	0	54	2
14-20 June	584	96	0	0	0	0	24	4
21-27 June	964	100	0	0	0	0	0	0
28 June-4 July	2,172	93	49	2	0	0	117	5
5-11 July	2,249	97	0	0	0	0	71	3
12-18 July	2,328	94	8	<1	136	6	16	<1
19-25 July	1,395	87	39	2	93	6	81	5
26 July-1 Aug.	1,553	89	16	1	99	6	82	4
2-8 Aug.	1,485	86	17	1	203	12	27	1
9-15 Aug.	1,164	80	144	10	137	9	13	1
16-22 Aug.	-	-	-	-	-	-	-	-
23-29 Aug.	-	-	-	-	-	-	-	-
30 Aug.-5 Sep.	1,130	57	776	39	62	3	32	1
6-12 Sep.	1,081	33	2,221	67	0	0	0	0
13-19 Sep.	1,271	56	447	19	513	23	40	2
20-26 Sep.	1,850	72	735	28	0	0	0	0
27 Sep.-3 Oct.	1,964	76	613	24	0	0	1	<1
4-10 Oct.	2,182	90	234	10	0	0	0	0
11-17 Oct.	1,283	75	412	25	0	0	0	0
18-24 Oct.	1,537	71	629	29	0	0	0	0
25-31 Oct.	440	44	560	56	0	0	0	0
1-7 Nov.	1,023	60	683	40	2	<1	7	<1
8-14 Nov.	1,057	55	855	45	0	0	2	<1
15-21 Nov.	1,232	68	493	27	0	0	80	5
22-28 Nov.	439	99	0	0	0	0	5	1
Totals	33,915	74.14	8,931	19.52	1245	2.72	1,653	3.62

APPENDIX D

Prey items of Shiny Cowbirds (minutes and percent of observation), southwestern Puerto Rico, 1987

Appendix D. Prey items of Shiny Cowbirds (minutes and percent of observation), southwestern Puerto Rico, 10 May- 28 November 1987 (n= 29,298 minutes; ca. 488 hrs.).

Period	Caterpillars		Berries		Seeds		Flowers & Foliage of Mesquite		Corn & Grain	
	min.	%	min.	%	min.	%	min.	%	min.	%
31 May-6 June	1,007	100	-	-	-	-	-	0	-	0
7-13 June	1,367	100	-	-	-	-	-	0	-	0
14-20 June	494	96	18	4	-	-	-	0	-	0
21-27 June	645	96	26	4	-	-	-	0	-	0
28 June-4 July	740	56	551	42	-	-	-	2	20	2
5-11 July	1,807	94	122	6	2	<1	-	0	-	0
12-18 July	894	82	57	5	144	13	-	0	-	0
19-25 July	662	81	20	2	72	9	35	4	33	4
26 July-1 Aug.	276	56	38	7	176	35	-	2	7	2
2-8 Aug.	559	68	53	7	191	23	-	2	17	2
9-15 Aug.	236	23	13	2	291	28	321	31	67	16
30 Aug.-5 Sep.	-	0	-	4	62	4	712	46	772	50
6-12 Sep.	-	0	-	0	-	0	371	16	1,900	84
13-19 Sep.	409	24	-	0	-	0	777	46	515	30
20-26 Sep.	837	44	-	0	112	7	215	12	633	37
27 Sep.-3 Oct.	1,186	66	-	0	-	0	93	5	525	29
4-10 Oct.	1,547	86	25	1	21	1	-	0	208	12
11-17 Oct.	766	68	44	4	62	5	-	0	287	23
18-24 Oct.	638	42	74	5	255	17	5	<1	559	36
25-31 Oct.	182	24	86	11	113	5	-	0	388	50

Appendix D. Continued.

Period	Caterpillars min.	%	Berries min.	%	Seeds min.	%	Flowers & Foliage of Mesquite min.	%	Corn & Grain min.	%
1-7 Nov.	158	12	187	14	273	21	111	8	584	45
8-14 Nov.	384	31	58	5	57	5	-	0	715	59
15-21 Nov.	588	49	149	12	54	5	-	0	404	34
22-28 Nov.	173	89	22	11	1	<1	-	0	-	0
Totals	15,555	53.09	1,543	5.27	1,886	6.44	2,680	9.15	7,634	26.05

APPENDIX E

Weekly rainfall during study period, southwestern Puerto Rico, 1987

Appendix E. Weekly rainfall at the Cabo Rojo National Wildlife Refuge, southwestern Puerto Rico, 3 May- 28 November 1987.

Week Period	Rainfall mm (inches)
3-9 May	5.59 (0.22)
10-16 May	11.94 (0.47)
17-23 May	12.19 (0.48)
24-30 May	38.66 (1.53)
31 May-6 June	99.06 (3.90)
7-13 June	0.00 (0.00)
14-20 June	0.00 (0.00)
21-27 June	122.43 (4.82)
28 June-4 July	1.27 (0.05)
5-11 July	0.76 (0.03)
12-18 July	0.00 (0.00)
19-25 July	8.38 (0.33)
26 July-1 August	3.56 (0.14)
2-8 August	0.00 (0.00)
9-15 August	0.00 (0.00)
16-22 August	14.99 (0.59)
23-29 August	19.56 (0.77)
30 August-5 September	42.16 (1.66)
6-12 September	3.05 (0.12)
13-19 September	27.69 (1.09)
20-26 September	56.39 (2.22)
27 September-3 October	2.79 (0.11)
4-10 October	8.64 (0.34)
11-17 October	0.00 (0.00)
18-24 October	29.72 (1.17)
25-31 October	43.69 (1.72)
1-7 November	37.59 (1.48)
8-14 November	4.32 (0.17)
15-21 November	3.30 (0.13)
22-28 November	239.52 (9.43)

APPENDIX F

Activity budgets of Shiny Cowbirds (minutes and percent of observation), southwestern Puerto Rico, 1987

Appendix F. Activity budgets (minutes and percent of observation) for Shiny Cowbirds, southwestern Puerto Rico, 1987 (n= 50,597 minutes; ca. 843 hrs.).

Period	Behavior					
	Foraging		Preening & Resting		Drinking & Bathing	
	Min.	%	Min.	%	Min.	%
31 May-6 June	1,651	76	513	24	21	<1
7-13 June	2,391	77	703	23	6	<1
14-20 June	628	86	101	14	0	0
21-27 June	705	76	221	24	2	<1
28 June-4 July	1,725	59	1,146	39.4	46	1.6
5-11 July	2,080	67	972	31	66	2
12-18 July	1,343	61	832	38	21	1
19-25 July	1,099	65	580	35	8	<1
26 July-1 Aug.	780	47	850	52	20	1
2-8 Aug.	1,337	67	629	31	38	2
9-15 Aug.	1,439	69	614	30	25	1
30 Aug.-5 Sep.	1,707	75	573	25	13	<1
6-12 Sep.	2,650	68	1,181	30.5	58	1.5
13-19 Sep.	1,775	70	766	30	8	<1
20-26 Sep.	1,972	72	788	28	16	<1
27 Sep.-3 Oct.	1,888	72	738	28	8	<1
4-10 Oct.	1,861	73	684	27	21	<1
11-17 Oct.	1,174	67	605	33	11	<1
18-24 Oct.	1,644	64	910	36	11	<1
25-31 Oct.	904	74	322	26	3	<1
1-7 Nov.	1,327	70	574	30	8	<1
8-14 Nov.	1,241	64	681	26	16	<1
15-21 Nov.	1,211	65	650	35	6	<1
Totals	34,532	68	15,633	31	432	1

APPENDIX G

Date, caterpillar species, and host plants for larvae collections, southwestern Puerto Rico, 1987

Appendix G. Caterpillar collections (including species and collection number), habitat, species and substrate of host plants, location and date, southwestern Puerto Rico, 1987-1988.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
1	8 June	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Cabo Rojo NWR, ca. 2.5 KM SW of inter. of Rts. 303 & 301.
2	23 June	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
3	8 July	Melioptis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 4 KM NW of inter. of Rts. 303 & 301, proposed VOA site.
4	11 July	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 5 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
5	17 July	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 4 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
6	14 August	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 4 KM SE of inter. of Rts. 303 & 301, proposed VOA site.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
7	17 September	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 2 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
8	29 September	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 2 KM ENE of La Pargurea.
9	5 October	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 4.5 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
10	13 October	Melipotis ochrodes	mesquite woodland	Prosopis pallida	bark and crevices	Ca. 2.5 KM ENE of La Parguera.
11	30 June	Mocis latipes	mesquite woodland	Panicum maximum	leaf blades	Cabo Rojo NWR, ca. 2.5 KM SW of inter. of Rts. 303 & 301.
12	8 July	Mocis latipes	mesquite woodland	Cenchrus ciliaris	leaf blades	Ca. 4 KM SE of inter. of Rts. 303 & 301.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
13	11 July	Mocis latipes	mesquite woodland	Cenchrus ciliaris, Chloris inflata, Sporobolus pyramidatus	leaf blades	Ca. 5 KM SE of inter. of Rts. 303 & 301.
14	13 July	Mocis latipes	mesquite woodland	Panicum maximum	leaf blades	Ca. 3 KM ENE of inter. of Rts. 304 & 324 near La Parguera.
15	15 July	Mocis latipes	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
16	17 July	Mocis latipes	mesquite woodland	Cenchrus ciliaris	leaf blades	Ca. 4 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
17	25 July	Mocis latipes	mesquite woodland	Cynodon dactylon	leaf blades	Ca. 4 KM SSE inter. of Rts. 303 & 301 and ca. 1 1 KM of Punta Molino, proposed VOA site.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
18	13 September	Mocis latipes	mesquite woodland	Cenchrus ciliaris	leaf blades	Ca. 2.75 KM ESE of inter. of Rts. 303 & 301.
19	5 October	Mocis latipes	mesquite woodland	Cenchrus ciliaris	leaf blades	Ca. 4.5 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
20	12 November	Mocis latipes	mesquite woodland	Bothriochloa pertusa, Chloris inflata	leaf blades	Ca. 5 KM SE of inter. of 303 & 301.
21	15 November	Mocis latipes	mesquite woodland	Bothriochloa pertusa, Cenchrus ciliaris	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301, proposed VOA site.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
22	10 October	Spodoptera frugiperda	mesquite woodland	Cenchrus ciliaris, Chloris inflata, Sporobolus pyramidatus, Bothriochloa pertusa	leaf blades	Ca. 5 KM SE of inter. of 303 & 301.
23	5 October	Spodoptera frugiperda	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 4.5 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
24	15 November	Spodoptera frugiperda	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
25	12 October	Spodoptera frugiperda	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 5 KM SE of inter. of Rts. 303 & 301.
26	17 July	Spodoptera sunia	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 4 KM SE of inter. of Rts. 303 & 301, proposed VOA site.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
27	15 November	Spodoptera sunia	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
28	23 June	Spodoptera sunia	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
29	13 September	Spodoptera dolichos	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 2.75 KM ESE of inter. Rts. 303 & 301.
30	12 November	Spodoptera latisfacia	mesquite woodland	Bothriochloa pertusa, Chloris inflata	leaf blades	Ca. 5 KM SE of inter. of Rts. 303 & 301.
31	26 September	Polygonus leo savigny	mesquite woodland	Piscida carthagenensis	leaves	Along Arroyo Cajul, ca. 3 KM E of inter. of Rts. 303 & 301, proposed VOA site.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
32	12 November	Hyles lineata	mesquite woodland & coastal thicket	Boerhaavia diffusa	stems & leaves	Ca. 5 KM SE of inter. of Rts. 303 & 301.
33	9 November	Anticarsia gemmatalis	mesquite woodland & coastal thicket	Tephrosia cinerea	stems & leaves	Ca. 5 KM SE of inter. of Rts. 303 & 301.
34	12 November	Anticarsia gemmatalis	mesquite woodland & coastal thicket	Tephrosia cinerea	stems & leaves	Ca. 5 KM SE of inter. of Rts. 303 & 301.
35	6 October	Thecla simaethis	mesquite woodland	Cardiospermum halicacabum	seeds of pods	Cabo Rojo NWR, ca. 2.5 KM SW of inter. of Rts. 303 & 301.
36	5 October	Spodoptera frugiperda	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
37	23 June	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
38	23 June	Unknown (Geometridae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
39	13 July	Unknown (Noctuidae)	mesquite woodland	Panicum maximum	leaf blades	Ca. 3 KM ENE of inter. of Rts. 304 & 324 near La Parguera.
40	15 July	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 1.5 KM NW of inter. of Rts. 303 & 301.
41	25 July	Unknown (Noctudiae)	mesquite woodland	Cynodon dactylon	leaf blades	Ca. 4 KM SSE inter. of Rts. 303 & 301 and ca. 1 KM E of Punta Molino, proposed VOA site.
42	13 September	Unknown (Noctuidae)	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 2.75 KM ESE of inter. Rts. 303 & 301.
43	1 October	Unknown (Noctuidae)	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1987					
44	13 October	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 2.5 KM ENE of inter. of Rts. 303 & 301.
45	15 November	Unknown (Noctuidae)	mesquite woodland	Cenchrus ciliaris, Bothriochloa pertusa	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301.
46	12 June	Heliothis sp. (Noctuidae)	mesquite woodland	Bucida buceras	leaves	Ca. 5 KM SE of inter. of Rts. 303 & 301.
47a	1 June	Melipotis (Noctudiae)	littoral woodland	Pithcellobium unguis-cati	leaves	Ca. 1.5 KM S of inter. of Rts. 303 & 3301 in Corozo.
47b	2 October	Melipotis (Noctuidae)	mesquite woodland	Pithcellobium dulce	leaves	Ca. 2 KM WNW Boqueron.
48	15 November	Unknown (Noctuidae)	mesquite woodland	Melochia tomentosa	leaves	Ca. 4 KM SE of inter. of Rts. 303 & 301.

Appendix G. Continued.

Collection Number	Date	Species of Caterpillar	Habitat	Host Plant	Substrate	Location
	1988					
49	1 September	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 3 KM SE of inter. of Rts. 303 & 301, proposed VOA site.
50	7 September	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 2 KM SE of inter. of Rts. 303 & 301, proposed
51	7 September	Spodoptera eridania	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 2 KM ENE of La Parguera.
52	7 September	Unknown (Noctuidae)	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 2 KM ENE of La Parguera.
53	7 September	Spodoptera eridania	mesquite woodland	Bothriochloa pertusa	leaf blades	Ca. 2 KM ENE of La Parguera.

VITA

Paul Michael McKenzie was born 21 March 1950 in Frostburg, Maryland. He attended grade school at St. Patrick's Grade School, Mount Savage, Maryland, and graduated from Bishop Walsh High School, Cumberland, Maryland, in May 1968. In August 1968, he entered Allegany Community College, Cumberland, Maryland, and transferred to West Virginia University, Morgantown, West Virginia, in August 1970. He received a Bachelor of Science in Wildlife Management from West Virginia University in August 1972.

In December 1976, Paul was married to the former Miss Becky Futrell of Baton Rouge, Louisiana. On 16 March 1981, he was ordained into the gospel ministry at Evangel Temple, Baton Rouge, Louisiana.

In 1983, Paul entered Louisiana State University, Baton Rouge, Louisiana, where he received a Master of Science in Wildlife Management in December 1985. In June 1986, Paul reentered Louisiana State University, Baton Rouge, Louisiana, and is currently a candidate for the degree of Doctor of Philosophy in Wildlife and Fisheries Science.

From February through May 1990, Paul worked as a Wildlife Biologist in the U.S. Fish and Wildlife Service's Student Cooperative Education Program and was stationed at the Columbia Field Office, Columbia, Missouri.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

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Title of Dissertation: Habitat Use, Movements, and Behavior of Shiny Cowbirds in Southwestern Puerto Rico

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